Municipal and County Engineering

DESIGN, CONSTRUCTION, OPERATION AND MAINTENANCE OF ALL PUBLIC WORKS

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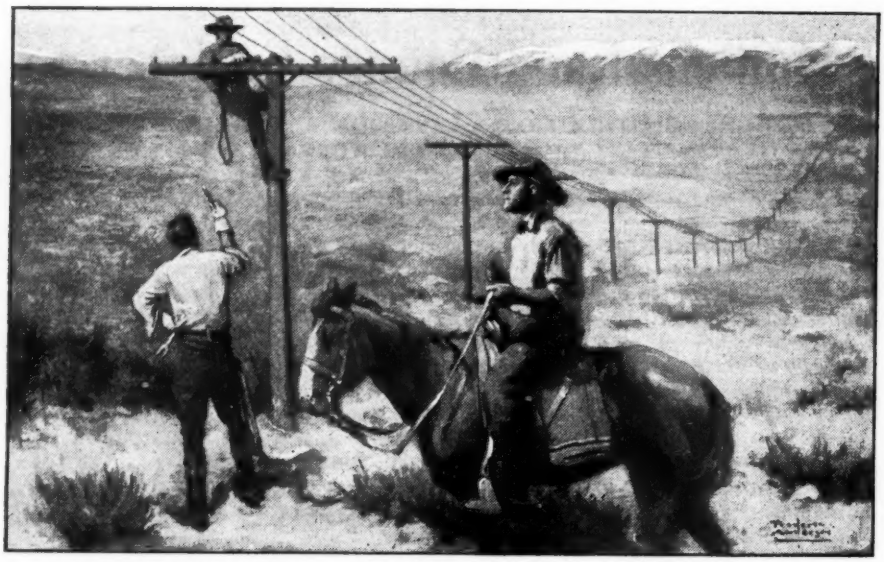

The Bell System's transcontinental telephone line crossing Nevada.

Highways of Speech

Necessity made the United States a nation of pioneers. Development came to us only by conquering the wilderness. For a hundred and fifty years we have been clearing farms and rearing communities where desolation was—bridging rivers and making roads—reaching out, step by step, to civilize three million square miles of country. One of the results has been the scattering of families in many places—the separation of parents and children, of brother and brother, by great distances.

To-day, millions of us live and make our success in places far from those where we were born, and even those of us who have remained in one place have relatives and friends who are scattered in other parts.

Again, business and industry have done what families have done—they have spread to many places and made connections in still other places.

Obviously, this has promoted a national community of every-day interest which characterizes no other nation in the world. It has given the people of the whole country the same kind, if not the same degree, of interest in one another as the people of a single city have. It has made necessary facilities of national communication which keep us in touch with the whole country and not just our own part of it.

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DEVELOPMENTS IN CONCRETE PAVEMENT DESIGN

By Willis D. P. Warren, of Holbrook, Warren & Van Praag, Civil Engineers, Millikin Bldg., Decatur, Ill.

The general use of concrete as a paving material did not begin until a little over ten years ago, for, as a matter of fact, the total yardage of concrete pavements laid in 1912 was reported as only 5,381,218. When it is realized that the total concrete pavement yardage laid to date is in excess of 300,000,000, it may be seen that the growth of this type has been most phenomenal.

In considering this great increase in concrete pavement yardage, it may be of interest to review developments in design, and to endeavor to point out certain principles which should be emphasized on future work.

Early History of Design

The use of concrete as a paving material was the result of early experience with concrete built for walks and driveways. Many of the first pavements were of a thickness and mix ordinarily used on such classes of construction, and little regard was paid to the necessity for richer mixes, and practically no thought given to the importance of structural design.

There was a period of several years after early construction began before it was fully realized that the structural design of a concrete pavement involved complex problems of unusual occurance.

Literature of Ten Years Ago

As indicated in 1913, the lack of commonly accepted principles in the design of concrete pavements, brief extracts from the literature of ten years ago will be of interest. This situation was pointed out in an editorial published in Municipal Enginering for July, 1913, here quoted in part as follows:

"Probably the most difficult of all the concrete construction problems which engineers have had to face and solve is the proper design and construction of concrete pavements. Although only a comparatively recent innovation, attended with the usual costly failures and experiments of any new type of construction, surprising progress has been made. Engineers can recall the difficulties that marked the early stages of the simplest types of concrete structures which taught the lesson that concrete is merely a structural material, subject to certain laws governing strength, elasticity, etc., and they have profited by this initial lesson."

"It is obvious at a glance that the considerations involved in the construction of concrete pavements are more complex and multitudinous than in building or foundation work, but it is not generally understood as yet just where the marked differences in the two types of construction lie."

It is quite interesting to note a portion of the Report of Com. XIII, National Conference on Concrete Roads, 1914, and the fact that the usual practice of the day was emphasized, rather than any carefully tested principles of design.

Following is a brief summary of the Report of Com. XIII:

"Because of the fact that the members of this Committee have had their attention directed chiefly to the conditions obtaining in the northern states, it is not without some misgivings that they suggest the following as conforming to the best practice.

1. Where the width of roadway is not greater than 16 feet, with a porous subsoil, subgrade in good condition and well packed and with loads not exceeding 6 tons, including the vehicles, a thickness of 5 ins. at the edge of the slab and 7 in. at the center is sufficient without reinforcement, using slabs not greater than 16 ft. sq . . . ."

Reference was also made to concrete pavement design in the editorial columns of Engineering & Contracting under date July 9, 1913, in part as follows:

"Concrete road construction is in the development stage. Few of its requirements have been settled definitely. The use of expansion joints is in particular undetermined by practice. General opinion holds such joints to be necessary but deplores the necessity. . . ."

"It is apparent from the evidence of experience so far with concrete roads that joints have not caused undue worry. The article which we publish in this issue aims to demonstrate that they are not to be avoided at all hazards, but should be accepted as a safe and economical structural resort. We believe that the argument of this article is well worth careful consideration."

Bates Experimental Road

In 1920, the Bates Experimental Road was started. The tests in connection with this road have extended over a period of time sufficient to give us much valuable data, and in fact probably the most valuable yet collected. While other experiments have been undertaken on a comprehensive basis since the Bates Road was

started, the work has hardly progressed to the point reached by the Bates tests.

The experiments being conducted by the U. S. Bureau of Public Roads at the Arlington Experiment Station in Virginia are aimed primarily at the obtaining of information which is of importance in connection with the structural design of roads, and offer data of immense value to future construction.

The reports on the Bates Road tests are full of data of the most vital importance in the economical design of concrete pavements. They confirm in no uncertain manner the wisdom of this scientific investigation, and suggest the value of future studies and tests.

Application of New Data

The writer desires to emphasize that it is "the application of information and data" and not the data itself which is of value, for we frequently have in our offices much information and data of interest and importance, but until we apply it to the practical problems at hand, it is in reality of little value. Not only can we apply much available data of today to the problems of concrete pavement design for highways, but we can also apply such data to the problems of concrete pavement design for city streets.

The more general use of *joints*, of *circomferential reinforcement*, of *denser concrete*, and also a wider *range* in *selection* of *materials*, are factors to be carefuly considered in the design of future pavements.

It is the belief of the writer that full use has not as yet been made of the data at hand as the result of the Bates, Arlington and other experiments.

Dense Concrete

Dense concrete can be produced by tamping, which assumes a dry mix, and therefore not proper for pavement construction or it can be produced by removing excess water, and by mechanical processes.

In removing such excess water the concrete is necesarily compacted and thereby its density increased, as well as its strength. Removal of excess water from concrete pavement materials is recognized as good practice. However, such removeal, when accompanied by some movement of the mass of concrete, both laterally and vertically will produce a mixture of very substantially increased density and strength.

The possibilities in this direction appear to justify considerable further study, as any feasible plan which will permit of so working the surface of the pavement as to force the coarser material from the surface, will afford a much wider range in the selection of materials. In this way a less durable quality of stone may be used for the pavement proper, provided a suitable quantity is provided for the wearing surface. The removal of all excess water is very essential.

Longitudinal Joints

In considering longitudinal joints, it will be of interest to contemplate the extent to which joints may be properly used on our wider pavements. Consider the recent design of two different concrete pavements. One improvement was planned and constructed 56 ft. in width, 12 ins. in thickness, with fabric reinforcement and with longitudinal constructing joint in the center. The other was constructed 18 ft. in width and may be further described as Sections 48 and 49 on the Bates Road. These Bates Road sections were constructed 5 ins. thick, both being provided with longitudinal joints, and one with circumferential reinforcing in 9 ft. by 25 ft. sections, the other with similar reinforcing in 18 ft. by 25 ft. sections. When it is understood that these 5 in. pavements, so designed, withstood the tests and were reported in good condition after completion of the traffic runs on Sept. 2, 1922, when the last of 5,000 night applications of the 8,000 lb. wheel load was imposed on the various sections, it will be more clearly recognized that longitudinal joints in a pavement are not necessarily a structural weakness.

While these comparatively thin pavements withstood the tests on the Bates Road, it is not necessary or proper that we adopt a 5 in. slab. However, it is proper that we give thought to the valuable data assembled as a result of such tests, and apply it in the design of future improvements. It is difficult to conceive of a traffic condition which would require a pavement section 12 ins. in thickness.

The writer, with the late S. T. Morse of Carlinville, Ill., designed one of the earliest pavements built with a longitudinal center joint. This pavement was constructed at Carlinville in 1913, and while it possessed some of the defects common to pavements of that time, it demonstrated beyond doubt the value of the longitudinal joint. With practically no maintenance, it is still in good condition.

Since that time Mr. Morse, until the time of his death in 1921, and also the writer, urged the adoption of a longitudi-

nal joint, particularly on highway work. This early experiment at Carlinville was of value in assisting to establish the principle that longitudinal joints are not to be avoided at all hazards, but should be accepted as a safe and economical structural resort.

The use of longitudinal joints, with the present class of traffic, is not to be avoided as it might have been at one time. There is sound argument in favor of several longitudinal joints for city pavements, one located about 9 ft. out from each curb, and one or more proper intervals between these two, each independently divided section being reinforced with circumferential, or other proper reinforcing.

The following reference to this important feature is quoted from Bulletin No. 18, Bates Experimental Road, prepared by Clifford Older, Chief Engineer:

"On sections where longitudinal joint was provided, the edges of the pavement slabs lifted on an average of about ¾ of an inch, while during the same period the center lifted but an average of about ¼ of an inch. Many sections not provided with longitudinal joints showed approximately the same behavior. All such sections when examined in the spring were found to be cracked longitudinally. A few sections lifted at the edges about ¾ of an inch and at the center about ½ of an inch; these sections showing no discernible longitudinal cracks when examined in the spring . . Mathematical analyses indicate that it is likely to be economically impracticable to design wide slabs of sufficient strength to avoid breaking longitudinally when the edges only are supported."

From the above it may be seen that the use of longitudinal joints and circumferential reinforcing offers exceptional opportunity for more economical and practicable design.

Circumferential Reinforcing.

Many observations and tests have demonstrated the fact that a pavement slab does not receive subgrade support throughout its entire area.

A separation of the subgrade and the slab is to be expected as is evidenced by both the Bates and Arlington tests, and for this reason the use of smaller independently divided slabs with circumferential reinforcing, will prove far more effective and economical in supporting and distributing the weight of traffic.

The following extract from Bulletin No. 18 Bates Experimental Road is of peculiar interest in this connection:

"The results of these observations are of considerable interest. They show distinctly a periodic separation of the pavement slab and the subgrade due to warping of the slab under temperature changes which will be described later. They show, also, to a very marked extent erratic variations due in all probability to uneven settlements of the subgrade . . It is not believed that any economically practical method of compacting a subgrade may be applied with reasonable economy to secure absolutely uniform results."

This data is confirmed by the Arlington investigations, as follows:

"Without going into the details of the test, this curve shows very plainly that the bearing value of a soil having penetrations of the bearing block equal to 0.1 in. varies greatly with the size of the bearing block and that when small bearing areas are used the results are far higher and not at all indicative of the bearing value of the soil for supporting the pavement. This is very important for it points out to us the futility of attempting to make bearing value tests for roads with bearing areas having less than 2 sq. ft."

In the judgment of the writer, the use of one or more longitudinal joints, with necessary transverse joints, with each independently divided slab strengthened with circumferential reinforcing, will be but an intelligent application of the principles above set forth.

Conclusion.

From the above brief discussion, it is readily apparent that great progress has been made in the field of concrete pavement design, and that data of immense value has been collected during the past ten years. Concrete pavement design may now be made on the basis of known data of fundamental importance.

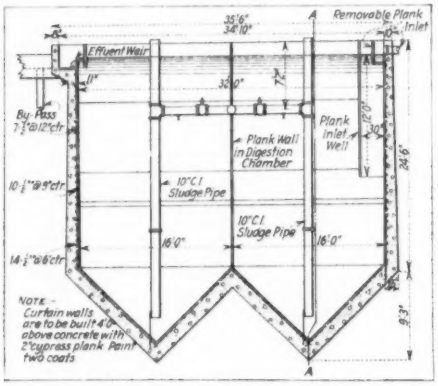
Without neglecting any of the important requirements in the design and construction of concrete pavements, greater emphasis can very profitably be put on the features discussed herein.

A little more vision of the magnitude of our future paving program, and a proper application of all available data in design, will be of immense value to future construction.

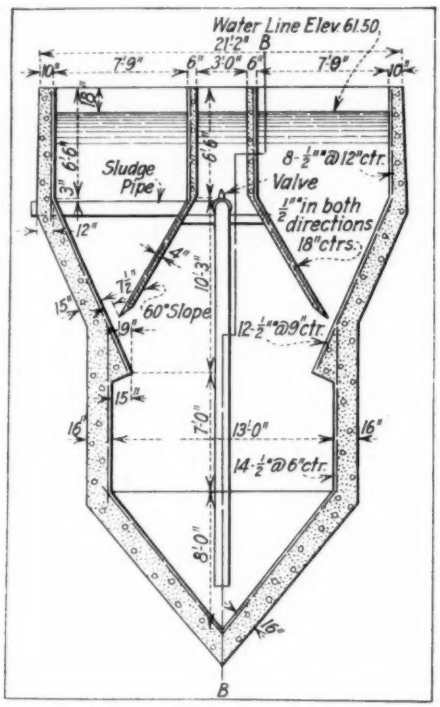
COMPLETE SEWAGE TREATMENT FOR CITY OF 3,000, DELAVAN, WIS.

By W. A. Peirce, Sanitary Engineer, Delavan, Wis.

Delavan, Wisconsin, a progressive city of 3,000 population, has for many years discharged its sewage untreated into the outlet of Delavan Lake at a point a few hundred feet above a mill pond formed by the damming of Turtle Creek and the above mentioned outlet. This lake is used each summer by many thousands of people for bathing and boating. The usual result of such a practice was observed here; nuisances in form of odor and objectionable sights. Following many complaints by residents to local authorities and to the State Board of Health, the Common Council decided to construct a treatment plant and the writer was ordered to prepare plans.

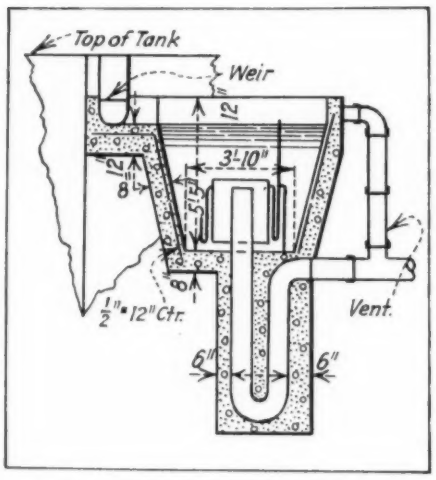

Effluent Weir
Removable Plank Inlet
By-Pass
Plank Wall in Digestion Chamber
Plank Inlet Well
10" C.I. Sludge Pipe
10" C.I. Sludge Pipe
16'0"
16'0"
NOTE:- Curtain walls are to be built 4'0" above concrete with 2" cypress plank. Paint two coats

LONGITUDINAL SECTION THROUGH PRELIMINARY TANK

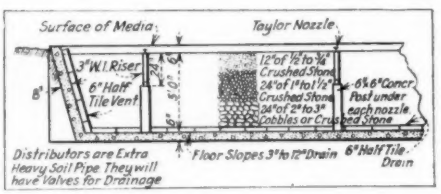


TRANSVERSE SECTION THROUGH PRELIMINARY TANK

Gagings showed a discharge of about 75,000 gals. per day from 215 houses and stores. After investigating conditions and testing the sewage the State Sanitary Engineer (at that time Mr. E. J. Tully) recommended in 1919 the installation of a tank of three hours' detention period, followed by percolating filters and specified minor requirements. It was essential that a plant be designed to produce a very stable effluent as the discharge is into a stream having practically no flow in the summer.



SECTION THROUGH DOSING CHAMBER


Surface of Media
Taylor Nozzle
3" W.I. Riser
6" Half Tile Vent
Crushed Stone
Crushed Stone
Post under each nozzle
Distributors are Extra Heavy Soil Pipe They will have Valves for Drainage
Floor Slopes 3" to 12" Drain
6" Half Tile Drain

TYPICAL FILTER SECTION

The basis of the design for the various units is as follows:

1. *Preliminary Treatment Tank.* Two compartment, rectangular sedimentation chamber designed for three hours' detention based on daily flow of 210,000 gals. Sludge compartment designed for 1.8 cu. ft. per capita, based on 3,000 population, double hopper bottom.

2. *Dosing Chambers.* These are of 75 cu. ft. capacity, discharging at about 13 minute intervals through 8 in. siphons, one for each filter unit.

3. *Filters.* Five units of trickling filters are provided with 5 ft. (average) media composed of graded crushed stone, two units to be installed at present. The dosage above stated is equal to ½ in. depth over the filter area which is rated at 2,000,000 gals. per acre per day.

4. *Secondary Tank.* This is a small rectangular tank for one hour detention with double hopper bottom and an effective depth of 4½ ft.

5. *Operating Conditions.* Sewage flows under a creek through a 6 in. cast iron siphon 600 ft. long with a drop of 1.6 ft. to the flow line of the tank. This gives a velocity of 1.1 ft. per second and discharge of 150,000 gals. per day. Conditions at the inlet end are such that the head may be built up to 12 ft. thus providing for the increased flow in the future. The siphon is in duplicate with two cleanouts in each line.

The plant is located in an abandoned city gravel pit, the topography giving rise to a rather unusual layout.

General practice is followed in the design, the only special construction being the preliminary tank. This is constructed much the same as the Imhoff. There is, however, a wooden partition transversely through the digestion chamber and gas vent midway between the inlet and outlet ends of the tank. Sewage is introduced into the lower compartment through a wooden shaft and flows upward through the slots and then horizontally to the outlet weirs. This type of tank has alleviated troublesome conditions at a number of plants in Wisconsin, but should it not operate satisfactorily with the local sewage it can be readily converted into an Imhoff. Subsequent to approval of plans by the State Board of Health, the contract was awarded to John Braman & Son of Jefferson, Wis., and is now under construction.

CURING A "SICK" SEWER SYSTEM AT INDEPENDENCE, MISSOURI

By Leon B. Reynolds, of Burns & McDonnell Engineering Co., Interstate Bldg., Kansas City, Mo.

Independence, Mo., is a city of about 12,000 population, situated about nine miles east of Kansas City, Mo. The topography of the city is rather rough, with an extreme range of over 150 feet in elevation. The business section occupies the highest ground and the drainage flows in five different directions. These draws fall rapidly and, of course, do not carry much water except during wet weather, and are often entirely dry.

The original sewer system was designed about 1899 and four outlets were provided with sewage disposal plants. The backbone of the system has remained unchanged and lateral extensions have been added as the city has grown. The original sewage disposal plant for each outlet consisted of a shallow septic tank and a contact bed, one of the earliest installations of this type in the country. The septic tanks were circular radial flow tanks 5 to 8 ft. deep; the contact beds were originally filled with alternate layers of brick and coke breeze. By the year 1908 the coke breeze had broken down and the beds had become clogged; at that time the filling material was removed and the beds were filled with layers of sand, stone, gravel, and brick. At the west plant a dosing tank and sprinkling filter were later constructed in order to purify the sewage more thoroughly. The contact beds were later abandoned entirely, the septic tanks ceased to function, due to their filling up with solids, and the sprinkling filter became clogged, due to excess of solid matter being carried over from the septic tank.

Early in 1921 the city engaged the firm of which the writer is a member to examine the sewer system and plants for treatment of sewage and to recommend the necessary improvements. A sanitary survey of the city was made to determine the number of houses connected to the present sewers. The authorities were startled to find that 1,500 houses, or more than half the total number in the city were not connected to sewers; of these 1,500 houses not connected, 700 fronted on streets where sewers were already laid and sewer service was available, and 800 were in localities where no sewers had been laid. The amazing discovery that nearly one-quarter of the population oc-

cupied residences unconnected with the sewers started an agitation to compel the use of sewers where available.

Practically all of the existing lateral sewers were found to be provided with flush-tanks, 101 being the total number. Of this total only thirty-two were found to be operating, forty-one were receiving no water due to the inlet being stopped up or turned off, and twenty-eight were not flushing due to leakage through the siphon or the walls of the tank. In addition to the waste by leakage in the twenty-eight which were not flushing, the water used by the thirty-two operating tanks would have been sufficient to allow each of the 101 tanks to discharge once every sixteen hours. This condition was also rather startling to the city, and may be common to other cities.

Due to the small amount or lack of flow during the summer in the draws used as final outlets the conditions below the sewage plants were very offensive. The north, east and south plants consisting of septic tanks and contact beds were practically not functioning at all and were entirely neglected, while the west plant, consisting of septic tank and sprinkling filter was neglected and its efficiency was low. Damage suits had been threatened and one suit had already been filed by landowners below the outlets and the city was facing considerable litigation. If the Missouri State Board of Health had actively and efficiently regulated the disposal of sewage from cities of that state the existing conditions would have been remedied long before. The most startling discovery of all was that the effluent from the inefficient west plant discharged into a draw about a mile and one-half above Fairmount Lake, located in one of Kansas City's amusement parks, on whose shore is the best natural bathing beach in the city. Physicians stated that they had treated numerous infections among bathers but the cause seemed to be unknown, and the public generally was not aware that the sewage from the west district in which the city hospital was located found its way into this lake. As soon as the real condition became public the owners of the amusement park threatened suit for damages unless the city installed a sterilization plant, and the city promptly installed a temporary plant of this kind to treat the effluent with liquid chlorine. In addition the owners of the amusement park treated the lake with liquid chlorine applied from a plant installed in a row-boat. The effect of these precautions was quickly noticed in the reduced baterial content of the lake water.

A bond issue was put up to the people on the basis of the preliminary report by the engineers recommending new treatment plants consisting of Imhoff tanks, sludge beds, dosing tanks and sprinkling filters for the north, east and south districts and ejector pumping plants for the west, southwest, and southeast districts. The engineers conducted an educational campaign for the bonds and they were voted in June, 1921, by a vote of 7 to 1. Contracts were awarded in September, 1921, to Ray & Son of Baxter Springs, Kan., for the construction work, and to Simplex Ejector Company of Chicago for the ejector equipment. The construction work was completed in August, 1922, and the plants have all been in operation since that time.

The south plant is designed for a flow of 500,000 gal. per day, the north plant for 200,000 gal. per day, and the east plant for 100,000 gal. per day. The settling chambers of the Imhoff tanks are designed for a two-hour retention period on the basis of the entire daily flow occurring during 18 hours with provision for reversal of flow.

The velocity of flow through the settling chambers varies from 0.003 to 0.008 ft. per second; the total depth below sewage level ranges from 19 ft. 8 ins. to 23 ft. 6 ins. The ratio between gas vent surface and sludge room surface is approximately 1:4. Sufficient capacity is provided in the sludge compartment up to 18 ins. below the slot for storage of 150 days' sludge.

Sludge is withdrawn under hydrostatic head of 5 ft. 6 ins. to 6 ft. upon sludge beds having areas of 280 to 360 sq. ft. per thousand population. The sludge beds have a surface sand layer 6 ins. thick and underdrains are 4-in. drain tile.

The dosing tanks are of the ordinary tapered type. The sprinkling filters are designed to operate at the rate of 2,500,000 gal. per acre per day. The best local limestone in sizes from ¾ in. to 2½ in. was used for filling material with a depth varying from 5 ft. to 5 ft. 6 ins. Distributors are of vitrified pipe encased in concrete; Merritt square spray nozzles are used and underdrains are 6-in. split drain tile. The total head through the plants from the sewage level in the Imhoff tanks to the invert of the main drain from the filters is 14.6 ft. at the north

plant, 14.4 ft. at the east plant and 17.8 ft. at the south plant.

Ejector sewage pumping stations were constructed to pump the sewage from the west, southwest, and southeast districts into sewers draining by gravity into the south treatment plant. The west district is relatively small and its sewage including that from the city hospital is now prevented from being discharged into the bathing lake. The southwest and southeast districts are too low to drain by gravity into existing sewers.

At each ejector station there are two Simplex ejectors of 75 gal. capacity, two motor-driven Gardner vertical compressors with short belt and idler drive and Westinghouse automatic pressure regulator control. The discharge lines are 6-in. cast iron pipe; at the west station the static head is 60 ft., at the southwest 24 ft. and at the southeast 56 feet. A moderate speed of 250 R. P. M. was specified for the compressors in order to secure maximum service and reliability with a minimum of maintenance and attendance. Some difficulty was encountered with the unloader equipment due to unreliability of the local power, and bleeder tanks were installed on the discharge lines from the compressors to relieve the pressure and allow the compressor to start against a smaller pressure after any interruption of power of more than 15 seconds.

The total cost of the three sewage treatment plants was $87,950 including land and the cost of the ejector equipment was $11,735. The plants are under the supervision of the Sewer Superintendent, Mr. E. M. Riddle, who was fomerly city engineer and who is giving the plants the attention which they deserve. Some difficulty has been experienced thus far with the Imhoff tanks due to foaming, but the sludge is being kept down by raking and spraying with water, and conditions are improving. A removal of from 70 to 75 per cent of the settleable solids is being secured and a good quality of sludge is being produced. The relative stability of the final effluent is showing a gradual improvement as the bacterial action in the filter beds becomes better established.

The failure to use sewers after they are built and the lack of proper handling of sewage treatment plants, as was found at Independence, is a common fault and really defeats the good results in sanitation that might be obtained by full use and proper operation of sanitary works.

THE BLOOMINGTON, IND., WATER SUPPLY PROBLEM

By Paul Hansen, of Pearse, Greeley & Hansen, Hydraulic and Sanitary Engineers, 39 W. Adams St., Chicago, Ill.

The Bloomington water supply problem has attracted widespread attention throughout the state of Indiana because of the presence of the State University in Bloomington, and because during the autumn of 1922 the shortage of water was unusually protracted and severe; but it also has some aspects from the psychological and technical points of view, principally the former, that should prove of interest to water works men.

To give as nearly as practicable in a short paper a clear account of the problem in proper perspective, I will endeavor to trace the history of the Bloomington water works, pointing out along the way the interesting and significant features.

The First Water Company

In 1892, when Bloomington had a population of about 4,500, a franchise was granted to one J. W. Shoemaker to construct and operate a water works plant at Bloomington. This franchise was immediately assigned to the Bloomington Water Works Co. This company developed a supply at the upper end of Spring Branch, several miles to the southwestward of the city. Without any records or satisfactory personal recollections at hand the specific considerations that influenced the selection of the source of supply are not known, but it is reasonably apparent that the promotors of the project were attracted by some springs issuing from the limestone at the head of the valley, and were further influenced by the fact that this was the nearest "visible" supply to the city. Obviously little thought was given to the question of tributary water shed, rainfall and run-off, but there was an appreciation of the fact that the springs did not at times have an adequate flow to meet the requirements of the city, and so a low earthen dam about 13 ft. high at the highest point was thrown across the valley. A pumping station was built just below the dam and pipes were laid to and within the city. The position of the dam, just up stream from a road, was apparently more determined by the road than by needed storage requirements. Unfortunately the dam was founded on Mitchell limestone, a formation which outcrops in a broad band, having a generally north and south direction and lying just to the west of Bloomington. This lime-

stone is extremely cavernous, and its entire outcrop is marked by many sinks and caves. There is probably no other place in the country except in the Mammoth Cave region of Kentucky where sinks form so conspicuous a feature of the landscape. To engineers, therefore, it is not surprising that water found its way around and under the dam in considerable quantities. However, the water consumption remained small and the source met the requirements of the city until 1899, when the first shutdown occurred on account of shortage.

New Company Formed

The Bloomington Water Works Co. had a short life. In 1894, two years after its formation, it went into the hands of a receiver, and remained in the receiver's hands until 1898. In that year the city water works company was incorporated and took over the water works under an arrangement whereby the city purchased a portion of the stock with the understanding that it would eventually purchase all of the stock as rapidly as funds could be made available, and this objective was consummated in 1902. This means of financing was employed because the city could not legally raise enough money through issuance of bonds to buy the water works outright. A similar scheme will be employed to finance the present proposed improvements.

The shortage of 1899 and the following year resulted in an attempt in 1901 to impound more water by raising the dam 12 ft., or to a maximum height of 25 ft. and by plugging the obvious leaks. But the reservoir continued to leak, and such additional water as it was able to hold failed to prevent shortages in 1901 and 1902 with a brief shutdown in 1902. Wet years and a generous spring flow took care of the next few years.

Another Dam Built

In 1904 and 1905 a sewerage system was installed which tended greatly to increase the use of water. To meet the increased demand the city council in the same years and without the formality of obtaining technical advice, built another dam 20 ft. in height a few hundred feet below the original dam with the expectation of intercepting and holding the leakage past the latter. At the same time a new pumping station was built below the lower dam and the old pumping station was abandoned. The lower dam, like the upper dam, was founded on Mitchell limestone, and the water in the lower reservoir, like that in the upper reservoir, found its way through cavities in the rock into the stream below. The net result of the undertaking was some additional storage, nominally 30,000,000 gals., but actually about half this. The city council built a rectangular water-tight concrete basin below the lower dam to catch the leakage past this dam and such as was not needed for city use was pumped back into the reservoir.

A Geologist Offers Advice

At this point it is interesting to note that Dr. E. R. Cummins, professor of geology at the State University, who had made an intimate study of the local geology, ventured out of the sheltered seclusion of his scholastic world and in 1904 gave before the Fortnightly Club a very clear analysis of the Bloomington water supply problem from the geological point of view. This was published in one of the local newspapers. Much to Dr. Cummins' surprise, the article was not accepted by many of the towns people at its face value; in fact, some were inclined to intimate, and did intimate in public print, that Dr. Cummins did not know what he was talking about, or that he was actuated by ulterior motives. It is also alleged that one prominent politician allowed that he, the politician, could look as far into the side of a hill as any professor at the University. However, Dr. Cummins was not easily dismayed, and if the Bloomington water problem is finally solved the credit belongs largely to him for his persistent efforts in enlightening the public.

The address before the Fortnightly club pointed out some characteristics of the local geology that it will be well to discuss before proceeding farther, as they will help to understand what follows.

The Mitchell limestone has already been referred to. It is relatively thin-bedded, has a total thickness of about 200 ft. and slopes, as do all the other rocks in this locality to the west southwestward, at a rate of about 30 ft. to the mile. Drainage throughout the area of the out-crop is very largely subsurface and in places streams of considerable size enter cavities in the rock and disappear. The area also reveals an interesting phenomenon of "stream piracy," so-called, by which drainage that once followed a surface stream has been diverted through underground water worn channels into other drainage areas to the westward. The net result is that actual drainage areas are not coincident with apparent surface

drainage areas. In fact, drainage lines are very difficult to determine. Furthermore the Mitchell limestone is so thoroughly honeycombed with water worn cavities and stratification planes that it is extremely hazardous if not impossible as a foundation for a dam.

Geological Conditions

Underlying the Mitchell limestone is the Oolitic or Bedford limestone with a thickness of about 40 ft., famous and growing more famous all over the country as a building stone. The outcrop of this rock ordinarily does not exceed ½ mile in width though there is a considerable area of outcrop projecting out to the eastward covering the greater portion of the area within the city limits of Bloomington. This rock is thick-bedded and massive with joint planes at wide intervals. The uniform texture of this rock, the ease with which it can be worked, combined with its massiveness constitute its valuable properties as a building stone.

Like all limestone the Bedford is water worn but the cavities are in the form of "mud seams" along joint planes relatively far apart. This rock, therefore, is more suitable as a foundation for a dam inasmuch as the seams are easier to find and easier to plug, but it nevertheless presents some elements of danger on account of leakage.

Below the Bedford limestone is the Harrodsburg limestone with a total thickness of about 90 ft. and an outcrop covering the higher ground over a width of several miles. This rock is quite thin-bedded and more or less water worn, but is not nearly so porous or cavernous as the Mitchell.

Underlying the Harrodsburg limestone is the Knobstone with a total thickness of about 600 ft. and outcropping over a wide area to the eastward. Within three to five miles of Bloomington the Knobstone outcrop is confined to stream valleys, notably Griffy's Creek, Muddy Fork, Jackson Creek and Stevens Creek. The upper 100 ft. of the Knobstone is a very dense, fine-grained sandstone with an argillaceous cementing material. It is soft and easily erroded and hence the valleys in which it is found are deep with steep side slopes. Freshly exposed Knobstone disintegrates readily, but the natural rock faces are more or less protected by case hardening. So long as it protected from the atmosphere it forms an excellent foundation for a dam or any other structure and it is practically bottle-tight against percolation. Furthermore, the configuration of the Knobstone valleys, that is steep-sided with flat level bottoms, is almost ideally adapted to the impoundment of water.

All these considerations relative to geology and drainage led Dr. Cummins to conclude that the valley of Griffy's Creek was the nearest, safest and most economical place to obtain an adequate water supply.

Returning to the history of the water supply—1904 to 1908 were a series of wet years when the water supply was adequate at all times, thus tending to allay popular and official concern. In the latter year occurred the most lasting shortage that had occurred up to that time and this continued into 1909. To relieve this situation water from a spring and run-off from a limited surface area of 1/3 to ½ mile was impounded about ¾ mile south the existing resivoir forming what is known as Weiner's Pond. The dam is an earthen structure with concrete core wall and 25 ft. in maximum height. The storage is estimated at about 50,000,000 gals. Water filled this reservoir for the first time in March, 1909. Apparently this reservoir leaks but little though some leakage has been observed, but not measured.

A Water Shortage

Again a series of wet years helped out the situation until 1913, when a shortage occurred in the late summer and as a result of the discussion that followed the mayor appointed a committee of 17 citizens to investigate. So far as known this committee did not have surveys made and did not have any technical advice other than that available from the geological and other departments of the university. as a result of their deliberations eleven favored a development in the valley of Griffy' Creek and five submitted a minority report in favor of a development in the valley below Leonard's Springs, about 2½ miles in southwesterly direction from the original supply. The presence of fairly large perennial springs, the rather favorable configuration of the valley below the springs for an impounding reservoir and its relatively high elevation with reference to the city as compared with Griffy's Creek made the Leonard's Springs proposition an attractive one to the lay mind. But the- complicated considerations of tributary drainage area, run-off, storage required, storage that could be made available, etc., were more or less lost sight of or at any rate their

true influence and proportions were not fully appreciated. One thing the minority of the committee did know, however, was that in Leonard's Springs valley there was a continuous flow of spring water nearly always, cool and clear, while Griffy's Creek went bone dry nearly every year and if it could be made to yield enough water it would be "only surface water." This consideration seemed conclusive and still seems conclusive to a great many. The fact that the absence of springs was an assurance of a definite drainage area ascertainable from surface topography and also an indication of the imperviousness of the rock, seemed to make no appeal.

University Installs Own Supply

Because of the uncertainty of the city supply the State University was under the necessity of installing a supply of its own in 1911. This was done by impounding a small arm of Griffy's Creek by means of a concrete dam that has proved practically bottle-tight. The tributary drainage area is one-third square mile and the capacity of the reservoir is about 40,000,000 gals., or 133,000,000 gals. per square mile of drainage area. During the past autumn which was an exceptionaly dry one, this supply was easily able to meet the requirements of the university, amounting to not less than 156,000 gals. per day, equivalent to a yeild of about 520,000 gals. per square mile of drainage area per day.

Report of First Expert

Because of differences in local opinion the city early in 1914 engaged the services of Morris Knowles, Inc., of Pittsburgh, to report on the most desirable new water supply for Bloomington. This organization investigated practically all possible sources of water supply, including three developments in Griffy's Creek, Leonard Springs, Jackson Creek, West Branch of the White River, wells in the valley of Bean Blossom Creek and further developments of the existing supply. As a result of a very full investigation, a recommendation was made in favor of a development on Griffy's Creek capable of yielding about 2,200,000 gals. per day as the most economical and the most reliable.

It is interesting to note in connection with the Knowles investigation that the services of Prof. W O. Crosby of Boston, were obtained to investigate geological conditions as affecting the water supply problem. In a very comprehensive and clearly written report he substantiated the findings of Dr. Cummins and definitely recommended against any reservoir in the Mitchell limestone, but indicated a belief that a reservoir in the Bedford or Harrodsburg might be successful, provided adequate precautions are taken.

After further consideration, the city decided in favor of a development at Leonard Springs, comprising an earthen dam with spillway 29 ft. above the valley bottom, thus forming a reservoir with a capacity of about 140,000,000 gals., a pumping station and a pipe line to the existing pumping station. On the basis of an assumed drainage area of 5.9 square miles which is probably several square miles in excess of the actual drainage area the yield in a dry year would be about 750,000 gals. per day. This added to the probable safe yield of existing reservoirs would be a total of about 1,000,000 gals. per day. Another dam could be located below the existing dam so as to take in additional drainage area and provide storage for 500,000,000 gals. approximately. Assuming the entire superficial drainage area available which it is probably not, the daily safe yield would be about 2,000,000 gals.

Report of Second Expert

In 1920 critical conditions again developed, but there was no shut-down. During this year, Messrs. Alvord and Burdick were employed to make an investigation of the best method of developing a new water supply, and their report confirmed the former recommendations of Morris Knowles, Inc., in favor of Griffy's Creek. However. the Alvord and Burdick report recommended a materially higher dam, namely, 52 ft. to the spillway, as against 33 ft. A decision in favor of this higher dam was based on a larger consumption than proposed in the Knowles report and on a long series of run-off records from a small watershed at Lexington, Ky., which records were not available at the time the Knowles report was prepared. A 52 ft. dam would impound about 1,750,000 gals. of water and will provide a safe yield of about 3.6 gals. per day, according to revised computations of Pearse, Greeley & Hansen.

No action was taken as a result of the Alvord and Burdick report, apparently because of a strong popular preference for Leonard's Springs. Why the city should fail to heed the recommendations of water works specialists of high standing is one of the vagaries of municipial psychology. The best explanation I can think of is that such reports are rarely

given the publicity they should be given. Sometimes this is due to the rather involved way in which engineering reports are written, but this can hardly be regarded as the case in the present instance. Certain it is that very little was known about either the Knowles or the Alvord and Burdick reports, even by members of the water works committee, and it is questionable if nine-tenths of the population had ever heard of them. Perhaps this may be food for thought in the matter of preparing and presenting engineering reports on municipal work.

Near Water Famine

In 1922 there occurred the most prolonged and bothersome shortage of record. It lasted from early in October until late in December, during which period industries were all cut off and water for general uses was pumped but three days a week and then only sparingly. Great quantities of water were shipped in on the railroads and water was peddled for as high as $1.00 per barrel. The water pumped was from the bottom of the reservoir and was highly turbid and odoriferous. -The coagulating and sedimenta tion plant were unable to effect clarification because this, too, was generally drawn down to a low level. Some stirring up of mud also no doubt resulted from emptying and filling of mains. Though water was held in reserve for fighting fires it was impossible to attain good pressure short of four or five hours because of the time necessary to refill the mains and because of greedy draft of water by consumers as soon as it would flow from faucets in order to fill bathtubs, washtubs, barrels, buckets and pitchers against the next shut-down.

Report of Third Expert

This near disaster of 1922 stimulated the public and the city officials to do something to avoid the possibility of another shortage in 1923. Pearse, Greeley & Hansen were employed to investigate the relative merits of a project on White River and a project on Griffy's Creek. It was now the point of view of the controlling element in the council that Leonard's Springs was definitely settled as being unsuitable for a new or additional water supply, hence the instructions to the engineers were limited to these two projects.

Pearse, Greeley & Hansen studied the two projects thoroughly and developed the fact that for any population and water consumption that might reasonably be anticipated for the future Griffy's Creek was unquestionably the more economical and suitable.

New Supply Recommended

For Griffy's Creek three modes of development were considered from which it appeared that a development having pumps and filters at the dam with a large equalizing reservoir on a hill near the city gave the lowest total annual charges and lent itself best to economical progressive development.

Each mode of development was considered with reference to (1) a minimum permissible development, (2) an intermediate development, and (3) a complete development. The minimum development presupposes the continued use of the existing supply up to the limit of its safe capacity and the maintenance of the new supply strictly as an auxiliary to meet requirements during periods of shortage. The intermediate project also presupposes the continued use of the existing supply, but provides more liberally for those features which cannot readily be enlarged such as the dam, main pipe lines and equalizing reservoir and would thus permit the use of the new supply as the only source of supply with but the addition of a pump or two and filters. The complete development represents a desirable development that will meet all requirements for about 25 years in the future with the exception of the reservoir which should meet requirements until about 1960.

The proposed method of financing permits of raising but $450,000, whereas it was originally supposed that as much as $600,000 would be raised. The city authorities took the point of view that pipe lines and pumps should be stripped to bare bones and that what remains should be devoted to building the highest dam possible. It is felt that the psychology of having an abundant supply of water will remove present criticism and apprehension and that pipe lines, pumps, etc., can be added more or less readily as needed or as money becomes available.

Details of New Project

In line with this policy Pearse, Greeley & Hansen are preparing detailed plans and specifications for a project comprising a dam, a pipe line from the dam to the city, and a small electrically driven pumping station at the dam. An equalizing reservoir near the city, together with the necessary pipe lines and a filter plont will be omitted for the present. With this arrangement it is anticipated that the city can continue with delivery service as good as it is receiving at the

present time, but with the assurance that there will always be a supply of water. An equalizing reservoir when built will greatly improve pumping economies and ensure good fire protection. A filter plant when built will provide a water always clear and colorless but even without filtration the physical characteristics of the new supply will be reasonably satisfactory and chlorination will take care of the somewhat remote possibility of contamination. The proposed pipe line from dam to city will be 16 ins. in diameter, regarded as the minimum size necessary to deliver enough water to supplement the existing supply during the next 20 years without undue friction losses. The cheapest possible connection will be made to the existing mains consistent with delivering the new supply to the district of large fire hazard and consistent with an economical development of a future improved distribution system which will give good fire and domestic service throughout the entire city and its probable future extensions.

The Dams Considered

In order to obtain a dam of maximum height and hence secure the maximum storage within the present financial limitations bids will be received on five different heights of reinforced concrete dams and two different heights for earthen dams. Bids will be received on both reinforced concrete and earth dams because preliminary estimates indicate that they lie fairly close together in cost. More alternatives with reference to height are being received on reinforced concrete constructions than on earth construction because the former type of construction is better adapted to successive increases in height than is the earthen dam. The considerations which led to limiting alternatives on earthen dam to but two heights namely, the minimum with a spillway of 24 ft. above the valley bottom and the maximum with spillway of 56 ft. above the valley bottom are interesting. Preliminary studies indicated the practicability and economy of building the lowest dam of compacted selected earth placed in layers. Suitable earth is available for the most part on the hillsides, but in limited quantities. A materially larger dam can most economically be built by hydraulic fill methods, utilizing the ample supply of mixed material in the valley bottom which is quite satisfactory for this purpose, but would not be suitable for a compacted embankment placed in layers. The conversion of any dam larger than the smallest into a high dam by means of hydraulic fill would be very awkward. In the first place the down-stream toe of the dam would be in the way of a cut-off trench for a high dam built by hydraulic fill methods and in the second place would interfere seriously with the deposition of core material in the right place. Even with the low dam it is contemplated that a portion of the down-stream toe must be removed to accommodate core material for the higher dam.

Computations also show that assuming that larger storage than that afforded by the lowest dam would be required in the relatively near future, it would be economical to build the highest dam rather than the lowest dam for the reason that building the highest dam as an addition to the lowest dam would cost about $119,000, or roughly somewhat over one-fourth more than the single development would cost. This difference results in part from sacrificing the spillway of the low dam which is necessarily an expensive structure and could not readily be utilized for the high dam, in part from greater unit costs for construction of the low dam and in part from an increase in equipment overhead on that portion of the enlarged dam built by hydraulic fill methods.

In conclusion it may be noted that there is nothing about the Bloomington problem of an extremely complex engineering nature, although the intimate relation of the problem to the local geology, the care and judgment involved in determining upon proper run-off figures and certain features of the designs for earthen dams are rather unusual.

The foregoing paper by Mr. Hansen was presented at the recent annual convention of the Indiana Sanitary and Water Supply Association.

FIELD EXPERIMENTS IN EARTH ROAD OILING IN ILLINOIS

By H. F. Clemmer, Engineer of Materials, Illinois Division of Highways, State House, Springfield, Ill.

Arrangements have been completed and plans are well under way for carrying out some extensive field experiments in earth road oiling during the coming summer near Cambridge, in Henry County, Illinois. The Illinois Division of Highways, in co-operation with Mr. J. H. Reed, county superintendent of highways, plans to construct an experimental oiled earth road of a number of sections employing the

different kinds and grades of oil commonly used in Illinois on some sections and oil in varying quantities on other sections and observing the results under actual traffic conditions. It is also planned to study other important factors entering into the construction of oiled roads among which may be mentioned the effect of soil and subgrade conditions, the effect of extremes of weather conditions and the methods of heating and applying oil.

Extent of Road Oiling

If all the oiled earth roads of Illinois were laid out in the form of a continuous stretch of road, they would make a highway 13,000 miles in length or one that would reach more than halfway around the globe. These roads in 1923 required for their construction 35,000,000 gals. of oil and involved a total cost of about $2,000,000. Approximately 14% of the total mileage of public roads in Illinois is now oiled and no doubt carries a much greater proportion than 14% of the total traffic.

The oiled earth road is not adapted to extremely heavy traffic nor to heavy truck or steel tired traffic, but under moderate automobile traffic this type of road when properly constructed gives excellent service. For this reason the oiled road is best suited for the secondary system of roads where the brunt of the traffic is carried by the paved trunk highway. However, due to the absence of paved roads in many sections of Illinois, the main arteries of traffic have been oiled in some cases with considerable success.

Oiled Earth Roads Popular in Illinois

Surface oiling of earth roads was first practiced in Illinois in about 1910 or 1911 and since that time has made rapid strides until at the present time it constitutes one of the most important methods of road maintenance in the state. This rapid development may be accounted for first by the lack of local supplies of stone and gravel which could be utilized for other types of roads. Second, the rapidity and ease of construction of oiled earth roads. It is usually possible for a county or township to oil and maintain its entire system of roads throughout a season without an excessive outlay of equipment and at a moderate expense. It is possible to drag an oiled earth road practically throughout the year. The oil prevents the surface from freezing tight and otherwise keeps it in condition for dragging when an ordinary earth road cannot be so maintained. Third, a properly constructed oiled earth road is very agreeable to traffic and this feature has contributed in no small degree to its popularity and the demand on the part of the public for its construction.

Problems in Road Oiling

Coincident with the rapid development of the oiled road has arisen a number of problems in connection with its construction and maintenance, among which may be mentioned the following:

1. What is the best kind and grade of oil for earth road treatment?
2. What quantity of oil and number of treatments per season are necessary for the maintenance of an earth road?
3. What are the best and most economical methods of construction, particularly as regards methods of heating and spreading oil, and the preparation of the road surface prior to applying the oil?
4. What effect has the character of the soil and subgrade conditions on the final results?
5. What are the effects of the extremes of weather conditions and what measures can be taken to preserve an oiled earth surface through long dry periods and through the spring "break-up?"

While earth road oiling in Illinois dates back but little more than ten years, it has been practiced in certain other states for a much longer period, but owing to the climatic and soil conditions, and the peculiar varieties of oil available, Illinois has benefited but little from outside experience and the methods of construction, maintenance and oil specifications which have come into use are almost entirely the results of her own experience.

In an effort to find a solution to some of the above mentioned problems and to effect a better and wider understanding of the best method of constructing oiled earth roads, under conditions existing and with materials available in Illinois. this experiment is being undertaken.

ABILENE (TEX) GAS AND ELECTRIC CO. COMPLETE MODEL PLANT

The Abilene Gas & Electric Co., has recently put into operation its new ice and electric plant at Abilene, Texas. The old Abilene electric plant was destroyed by fire in the spring of 1919 and almost immediately plans were begun for the construction of a new plant that would typify the best in modern developments in power house construction. Ground was broken for the new plant on Dec. 23, 1919, and it was formally opened Oct. 25, 1922.

The plant, in which are combined an ice plant and an electric generating station, is located about three-quarters of a mile from the center of Abilene. The electric station serves the City of Abilene and 27 other communities by a system of high tension transmission lines extending in the four directions, and comprising a total of 286 square miles in all. At the present time the company has 8,600 customers, and work has been started on an extension that will serve three more towns and will add 700 customers. The connected load is about 10,000 kilowatts, about equally divided between lighting and power. The peak loads average 2,000 kilowatts and the average daily output from the station is 27,000 kilowatt hours. The territory served is building rapidly and many lighting and power consumers are being connected. Among the power consumers are two plaster mills, six city pumping plants, one street railway system, five cotton gins, and several flour mills, ice plants, grain elevators, etc.

The plant is located on a 14 acre tract. There is a railroad siding from the Abilene & Northern Railroad running onto the property and the Texas & Pacific Railroad has a spur of track alongside of the property, with which the ice plant is connected by a conveyor for loading ice into cars. The plant building is 195 ft. by 115 ft., with a little more than half of the floor space devoted to the ice plant. The building is of reinforced concrete and hollow tile construction and is fireproof throughout.

The electrical generating equipment consists of two units, the first being a Westinghouse 2,500 kv-a turbine-generator with a direct connected exciter. The electrical characteristics of the unit are three phase, 60 cycles, and 2,400 volts. The steam conditions are 200 lbs, 150 deg. superheat and 28 ins. vacuum. The speed of the unit is 3,600 R. P. M. The condenser is Westinghouse with a surface of 4,500 sq. ft. The air and hot-well pumps are Westinghouse turbine driven and a motor-driven circulating water pump is provided.

The second unit is a General Electric 1,250 kv-a. turbine-alternator with the exciter independent and motor-driven. The auxiliaries of the second unit are a 3,000 sq ft. condenser made by the Wheeler Condenser and Engineering Co., a motor-driven hot-well pump, a motor-driven centrifugal pump, and a steam jet air pump of the two stage type.

The circulating water is handled by 65 spray nozzles arranged in clusters of 5 each. A booster pump is used in connection with the sprays. A pond was formed by installing a dam in a creek known as Cedar Creek and intake and discharge flumes leading to an intake crib were constructed.

As a reserve unit a steam-driven G-E. exciter was provided. A 75-kw. motor-driven D. C. generator furnishes current for the local traction company.

Current is generated at 4,150 volts and is distributed through eight feeder circuits. A 33,000 volt switching structure, provided with remote control oil circuit breakers and metering equipment is located on the southeast corner of the property and from it 33,000 volt transmission lines extend North, East, South and West. The switchboard was built by the Westinghouse Electric & Manufacturing Co.

The boiler plant consists of three 414 h. p. Stirling boilers, two of which are arranged in one battery with the third forming a one-half battery, but so arranged that the installation of another boiler will complete the battery. These boilers are equipped with Babcock & Wilcox superheaters for 150 deg. of superheat, and the plant carries a steam pressure of 200 lbs. The boilers are equipped with Duquesne burners of the combination oil and gas type installed under Dutch oven extensions to the furnaces. Gas is supplied at 150 lbs. pressure to a regulation station on the property where the pressure is reduced to 25 lbs. and then to a regulator in the gas meter room where it is further reduced to an 8 ounce pressure. Duplicate meters of 100,000 cu. ft. capacity, arranged for testing, are located in this room.

An oil unloading rack along the plant spur track accommodates two cars at a time. Oil is pumped from cars by a Tennant-Lovegrove motor-driven triplex pump into 160,000 gal. oil storage tank. Near the boiler room is situated an auxiliary oil tank with 1,200 gal. capacity from which a duplicate oil heating and pumping set heats and circulates the oil through the oil burner heaters. The oil burners are of the steam atomized type.

Water, which is obtained from either the City's supply or by gravity from a nearby lake, is pumped into a 7,300 gal. house service, elevated tank and is softened in a Booth water softener and rapid pressure filter. From the clear water reservoir the water is handled by a Yoeman centrifugal make-up pump to a Hoppes opened-feed water heater of 75,000 lbs. ca-

pacity. There are duplicated feed water pumps which are Cameron 4-stage centrifugal pumps driven by Terry steam turbines.

The boiler plant is equipped with recording flue gas thermometers, boiler feed water thermometers, and steam flow meters for each boiler, as well as a recording C02 meter and a Venturi meter on the boiler feed water.

In the engine room there are two York ammonia compressors of 75 and 40 ton capacity. To each of the machines is connected a York uniflow steam engine which operates condensing. The condensing equipment is a 1,000 sq. ft. condenser, with motor-driven air and condensate pump and motor-driven circulating water and booster pumps. A natural draft cooling tower with spray nozzles in the upper section is provided. Thirty-two stands of the flooded type of ammonia condensers and eight stands of distilled water coolers are placed directly under the tower.

Two freezing tanks, containing 1,600 300-lb. cans, are provided with compressed air hoists and vertical motor driven agitators. Water for ice making is taken from the condensate of the ice machine engines and the turbines of the electric plant and is boiled in a vacum type reboiler. Three charcoal filters and two cooling tanks are provided.

The day storage room has a capacity of 120 tons of ice, and directly over this room are located 8 cold storage vaults for commercial use. The vaults and the day storage are cooled by brine coils, the brine being supplied from either tank by motor-driven centrifugal pumps. An elevator is provided for the commercial vaults. Adjoining the day storage room is the season storage. The capacity of this room is 2,000 tons. It is cooled by direct expansion, the coils being placed on three sides and the ceiling. The insulation in all of the cold storage rooms consists of 5 in. corkboard with a mastic finish.

GRADES FOR ASPHALT PAVEMENTS AND PREVENTION OF CREEPING

By Monroe L. Patzig, Consulting Engineer, Des Moines, Iowa

Whether asphalt construction can safely be used upon the steeper grades does not depend upon creeping tendencies as much as is commonly believed.

To begin with, an asphalt mixture that will creep on level grades naturally will creep on steep grades. One that does not creep on level grades need not be expected to creep on steep grades when properly constructed. The creeping of this type of pavement on heavy grades is largely due to the inability to use proper construction methods, and for this reason we will consider matters tending to prevent creeping before the matter of grades.

I may say that the greater part of this creeping is caused by the lack of proper equipment and pains to prevent it. It is necessary for the purpose of bond, to have either a rough surface on the concrete base or a suitable bonding material between the concrete and the asphalt wearing surface. The reason for this is that a comparatively thin sheet of material is placed over the concrete. If there is no bond, temperature and traffic stresses will cause this sheet to move over the smooth concrete unless suitable bond be obtained otherwise. Methods other than roughened concrete have not been used to any great extent. One may think, therefore, that a thicker wearing surface, say from 5 to 6 inches, in thickness would not creep, and rightfully so. Such practice, however, is not followed at the present time and perhaps will not be on account of its higher cost.

I anticipate that some do not feel that this bond has so much to do with this trouble, yet it is my desire to impress this idea. It is so sometimes where the proper care has been exercised in preparing the surface mixture.

The mixture itself is many times, perhaps most of the time, responsible for this annoying defect. It may lack uniformity or proper design; one is as important as the other. Uniformity is essential from the raw materials to the finished rolling. Considerable variations in the asphalt cement cause non-uniformity. Carelessness in proportioning the mineral matter, rapid or large fluctuation in the temperatures, improper or irregular mixing of the materials, the dropping of unmixed aggregate or gobs of asphalt into the mixtures after they have been mixed, the lack of careful and uniform raking, and walking upon the freshly raked surfaces, are all important causes of trouble, and, last, but not least, is the pains taken in rolling the surface.

I wonder how many have ever figured out how little pressure is exerted on the surface even by a 10-ton tandem roller? Let us take for instance, a 10-ton roller with 2-3 of 20,000 lbs., or 13,333 lbs.,

spread over an area 60 ins. long by about 6 ins. wide or 360 sq. ins., this gives us only 40 lbs. per sq. in. The roller, or rollers, must work on the hot mixture immediately before it can possibly become chilled. All the rolling that is done after the surface once gets cold amounts to as much as that caused by a small boy on a pair of roller skates. Little does it seem to matter whether the roller be a large three-wheel roller or a smaller tandem roller. The rolling must be done while the material is hot and it must be done in such a manner that humps and depressions in the surface are rolled out.

There are those who insist upon rolling with a 10 to 15-ton 3-wheel roller, and this is all right so far as the additional compressive power is concerned, but without some cross rolling it is practically impossible to prevent a wavy surface. Furthermore, there is always a tendency with these big rollers to wait until the surface cools off. Much rests with the individual tendencies of the roller man, much more than with the roller.

As much might also be said of some of the other causes of non-uniformity, principally, however, of the operation at the mixing plant.

The contractors can do much along the line of remedying this situation by keeping their plants in better repair, or condition, at all times. They should install reliable thermometers of temperature controls, on various parts of their plants, and insist upon their men faithfully and continually carrying out their instructions which will produce good work. They must be more careful in their selection of raw materials and in combining them to secure the proper gradings. This requires more pains in purchasing the various grades of aggregate, proper proportions in their feed, and accurate weighing of the materials. The asphalt penetration must be kept more uniform than is often the case.

Just as important as the forgoing is the design or specification, for a poor mixture specified cannot make a good pavement if carried out.

There has been in the past much tempering with formulas or mixtures. It seems as though every engineer has attempted to specify a mixture different than some one else. Some of them are good, perhaps, but before results have been noted other mixtures have been substituted. This has been true especially with the asphaltic concrete types of pavements. Mixtures of asphalt dust, sand and rock in some cases up to ½ in. size, and others as large as 1½ in. It requires years to determine the soundness of any theories of mixtures and for this reason it is best to stick close to well tried formulas.

At the present time there is in progress an investigation of the cause and correction of shoving of asphalt pavements. In 1921 this investigation was undertaken by the Bureau of Public Roads, with the co-operation of the cities of New York (Boro of Manhattan), Philadelphia, Baltimore, Washington, and Detroit, and the Asphalt Association. No conclusions have as yet been drawn according to an article published in the 1921 Proceedings of the American Society for Municipal Improvements. A few extracts from this article may be of interest:

"In the first place shoving, or tendency to shove, is not an inherent characteristic of asphalt pavements, as evidenced by millions of square yards of satisfactory surfaces varying from one to forty years or more in age and subjected to all conceivable conditions of exposure and traffic."

"More often than not, when waves or deformations are noted in an asphalt pavement, most of the adjacent surface in the same line of travel and with the same exposure is found to be true to contour."

"Whatever the conditions are which make shoving possible, the primary cause of shoving is traffic, which produces a rearrangement of the mineral particles in the paving mixture to an appreciable depth from the surface down."

This article also goes on somewhat further regarding the effects of motor traffic.

To quote still further:

"Certain general conditions which tend to promote shoving by producing an unstable paving mixture are quite well understood, but it is believed that there may be much yet to be learned regarding the limits of such conditions. These and other conditions are listed below for the purpose of illustrating the complexity of the subject from a research standpoint."

Conditions Which Tend to Promote Shoving

Foundation Faults—1. Lack of support from below, causing local settlement of the foundation.

2. Uneven contour in foundation, causing variable thickness of asphalt paving mixture and consequent differences in compression.

3. Very smooth foundation which may promote slipping of the asphalt paving mixture over its surface.

Inferior Paving Mixture—4. Use of too soft an asphalt cement for the climate, traffic, or the grading of the mineral aggregate.

5. Use of too much asphalt cement in the paving mixture.

6. Poor grading of the mineral aggregate, which creates instability of the paving mixture irrespective of the consistency and percentage of asphalt cement with which it is mixed.

7. Use of an excess of rounded particles of mineral aggregate in the paving mixture.

Construction Faults—8. Uneven contour due to faulty spreading, raking, or rolling of the paving mixture during construction or lack of uniformity in the composition of the paving mixture.

9. Lack of proper initial compression during construction which may be due to use of too light a roller, too little rolling, to the mixture being too cold when rolled, or too great thickness of course for a single rolling operation.

10. Faulty repairs to service openings.

Exterior Causes—11. Absorption of an excess of oil or gasoline drippings, causing undue softening of the asphalt cement.

12. Gas leaks from mains below the pavement structure, causing undue softening of the asphalt cement.

The article goes on further to give details as to the selection of samples, collection of general information, specifications, paving plant and construction records, sampling and test records, and the tests to be made.

A suggestion was made by Mr. Dow that moisture coming up through the foundation into the underneath portion of the wearing surface is one of the most prolific causes of shoving. The writer is also of the opinion that non-uniformity of mixtures, causing fat spots or unbalanced gradings is of great importance.

One can realize, therefore, that there are many conditions to cope with to prevent creeping or shoving, but briefly, suitable foundations, uniformity and proper consistency of asphalt, careful proportioning of asphalt and various grades of mineral aggregate, careful treatment and mixing of the materials, and proper spreading and rolling, are the essentials to good construction.

Limiting Grades

Now, if the necessary pains have been exercised in preparing and laying the pavement, what are the limiting grades for asphalt pavements? Opinions on this matter differ greatly.

The results of a few recent inquiries as to the maximum grades deemed advisable for asphalt pavements, are interesting.

The City Engineer of Omaha, Neb., laid asphalt on a 15 per cent grade in 1922.

An engineer with considerable experience through the Eastern and Central States says that twelve per cent (12%) is considered about the maximum.

New Jersey limits the grades on this class of pavements to five per cent.

The writer has just recently examined a number of asphalt pavements on steep grades, the grades being 9 per cent, 10 per cent and 11.3 per cent. All of these have been in use for four years or more.

From the foregoing theories and facts, it is probably fair to say that the ability to secure proper construction or rolling limits the grade upon which it is safe to lay asphalt pavements. When it becomes impossible or impracticable to do the rolling properly the grade will be too steep.

It seems, therefore, that about 10% or 12% grades should be considered the limit for this type of construction.

Although a number of conditions have been cited tending to cause creeping of asphalt pavements, I have purposely emphasized the necessity of ample rolling of the surface. It is one of the requirements often, I might say nearly always, neglected and I feel that it has more to do with determining the maximum grade suitable to this class of paving than any other condition.

The foregoing paper by Mr. Patzig was presented at the recent annual meeting of the Iowa Engineering Society.

DUST SUPPRESSION ON GRAVEL AND MACADAM ROADS

By H. C. Smith, Michigan State Highway Laboratory, Ann Arbor, Mich.

Dust has ever been considered a nuisance on city or rural highways. The extent of the nuisance is dependent upon the density of traffic on the highway and the density of population and the valuation and character of property along the highway. Because of this relation, work in connection with the suppression of dust has been carried on much more extensively on city than on rural highways.

The desire of residents along city

streets to suppress dust has long been evidenced by the great amount of sprinkling and dust palliative work, as well as petitions for expensive pavements on streets, the traffic of which could be carried on less expensive pavements which, to be sure, are very dusty.

With the increase and change of character of traffic on rural highways and the higher valuation of property along the roads, all of which have tended to accentuate the dust nuisance, the highway builder finds himself confronted with the difficult but interesting problem of eradicating this nuisance.

Following the path of least resistance would dictate that we pave all roads with a dustless pavement as an effective and positive way of solving the problem, but the economics of the question will not permit of so careless a solution.

In these Central Western States where good material for gravel and macadam roads are found in abundance, and where the traffic on a very large mileage of our highway systems is such that it can be carried quite adequately on these types of highways, obviously and logically, this type of construction must be continued, forming an annual addition to the extensive systems of such roads already constructed on which the question of dust suppression is now recognized as a vital problem.

Although we might possibly justify the expense of this work on the grounds of eradicating a nuisance, we can retain the support of the public better and solve the problem more logically, if we at all times keep in mind the various advantages to be derived by the work.

The science of hygiene has established beyond the possibility of dispute that dust is decidedly injurious to health. Further, one need drive but little in dense traffic on a dusty road to be convinced that the dust causes a decided menace to safety, not only because of the lack of clear vision but also because of the natural tendencies of drivers to speed past one car after another in order to be rid of the dust. If needed, a citation of accidents on dusty roads which were clearly caused by the dust could be compiled readily to prove this contention.

At this point, it will be helpful to recall the fundamental principles of construction and maintenance of this class of highway. Essentially, a gravel or macadam road consists of an aggregate composed of fragments of stone or gravel sufficiently hard and tough to withstand the wear and blows of traffic, which fragments are cemented together by a cementing medium with a further stability in the macadam road due to the interlocking of fragments. Success cannot be expected in the case of either of these roads unless the materials required for the proper performing of these functions are at all times present. Inasmuch as the binding material in both cases is the fine material in the road crust, it is quite apparent that the removal of dust from the surface of the road injures the surface by reducing the amount of binder, and that the continued removal of this binder in great clouds of dust must necessarily be followed by a disintegration of the surface which shows up in the form of raveling of macadam roads, and of holes and also raveling of gravel roads. It is apparent, therefore, that dust suppression on gravel and macadam roads is necessary to convenience, health and safety of the traveling public, and also has a very marked tendency to preserve the compacted surface of the road which materially reduces the maintenance necessary to keep a good surface intact.

This item of saving is difficult of analysis in dollars and cents because of the variation in the traffic, the type of road in question, and the type of treatment used, but it is safe to say that this saving is sufficient to balance an appreciable amount of the cost of dust suppression in any case and in some cases quite to equal it.

Dust suppression on gravel and macadam roads is accomplished, either by the use of a bituminous surface or by the use of a dust palliative. For a macadam road, unquestionably, a bituminous surface is the most satisfactory practice, but on gravel roads, the dust palliative treatment is more common.

A bituminous surface consists of a thin superficial treatment of bituminous material, with or without the addition of pea gravel, sand, stone chips, or a combination thereof. Bituminous surfaces can be successfully applied on a macadam road using tar or asphalt, and the material is applied either cold or hot depending upon the consistency of the material used. Best results are accomplished by covering the bituminous material with a covering of stone metal of chips or gravel about ¼ to ⅝-in. in size. The amount of this material used should be sufficient to keep the bituminous material from remaining free to be picked up by the tires of vehicles, and yet should not be sufficient to

give a surplus of loose rolling stones on the road. Such a bituminous surface can be maintained for a series of years on a macadam road by retreating as it becomes necessary. At first such treatment is usually about 0.4 gal. per sq. yd. and retreatments about ¼ gal. per sq. yd.

It must be remembered in using a bituminous surface that this surface treatment cannot be used to correct irregularities in a poor surface but will effectively hold a good surface. It follows, therefore, that its use on a badly worn macadam road should be preceded by a thorough patching of the road to furnish a good surface. This patching can be done most satisfactorily with a mixture of broken stone and a bituminous material made especially for this patching work.

The success of a bituminous surface depends largely upon its adherence to the road and every precaution should be taken to accomplish this end. It is best, therefore, to construct such a surface on a road with a large exposure of flat surfaces of stone, as the bituminous material will adhere to these surfaces and hence be firmly connected to the road. All loose stone dust and foreign matter should be removed as a film of loose material will prevent the bituminous material from coming into contact with the stone surface which makes adhesion impossible. Finally, the surface must be dry, as a film of moisture also prevents adhesion.

In as much as effective retreatment of such a surface requires that a mosaic surface of large stone be uniformly present, each treatment should be uniformly applied so that a uniform exposure of the stone surface may be the result of the wear of traffic.

The problem of dust suppression on the gravel road has not been so easily solved. The conditions, in the case of the gravel road are not nearly so favorable for the use of a bituminous surface as in the case of macadam road. It is almost impossible to obtain a clean surface composed largely of a large surface of stones. This is due to the fact that the gravel road, composed of rounded particles, lacks interlocking and hence its stability is usually accomplished by a binder of fine material largely clay. This also makes it very difficult to secure a clean compacted surface inasmuch as the dust and fine material in the top surface of a gravel road, which is objectionable from the point of view of bituminous surface work, is the binding material for the top of the road. Bituminous surfaces, however, have been used in some states on gravel roads and it appears that the difficulties attending such work are most nearly eliminated by the following practice.

Where a bituminous surface is to be applied on a gravel road, the road should be shaped to the required cross-section and compacted. During the compaction under traffic, either with or without a roller, the ruts and holes should be kept filled so that a good even surface will result. The road should then be swept until it is free of dust and the bituminous material applied. Tar has been used most generally although some very satisfactory experimental work has been conducted with asphalt. About ½ gal. per sq. yd. is used for this treatment. A metal covering is then applied the same as in a bituminous surface on a macadam road. With this type of surface on a gravel road, it is necessary to adopt a patrol system of maintenance as holes in the road must be found and patched early, otherwise distintegration is rapid. This system of maintenance will depend on the type of gravel of which the road is built, and although it has been extensively used in some Eastern states its application in the Central Western states is new.

During the summer of 1921 the writer, under the direction of the Michigan State Highway Department, conducted a series of tests in connection with dust palliatives on gravel roads. In this series of tests, roads were selected throughout the state with a view to covering the normal of range of those major conditions which affect the dust nuisance on highways. Roads were, therefore, selected varying from light to heavy traffic, and varying from clean hard surfaces to surfaces covered with a great deal of loose material. So that comparative results of the various materials could be studied under like conditions, the same series of ten tests were conducted on each road. The series of tests consisted of the following:

Section A High Carbon Tar—¼ gal. per sq. yd.

Section B. No treatment.

Section C. Tar T-68—¼ gal. per sq. yd.

Section D Tar T-68—⅛ gal. per sq. yd.

Section E Light Oil—⅛ gal. per sq. yd.

Section F Heavy Oil—⅛ gal. per sq. yd.

Section G Cut-back Oil—¼ gal. per sq. yd.

Section H Cut-back Asphalt—¼ gal. per sq. yd.

Section I Flake Calcium Chloride.

Section J Granular Calcium Chloride.

In this series of tests, no endeavor was

made to obtain a bituminous surface and where one was obtained it was intended that it should uniformly disappear before the winter so the road could be carried through the winter and spring thaw period as a gravel road and the treatment repeated the following year if desirable.

As a result of this series of tests the following conclusions were drawn:

1. Any surface treatment of gravel roads for dust prevention should extend the full width of the traveled way rather than over a portion of the center of the road, such as 16 ft.

2. For general use as a dust palliative on Michigan gravel roads, calcium chloride is the most satisfactory from the point of view of general applicability, application by unskilled labor and adaptability to various types and conditions of road. It is impossible, based upon these service tests of one season, to reach conclusions as to its effectiveness and economy compared with other dust palliatives investigated.

3. No distinction can be made between granular and flake calcium chloride as to effectiveness.

4. Calcium chloride supplied in the 100 lb. bag containers is more economically handled than that supplied in the 350 lb. metal drum and it appears that it might be profitable for the necessary storage to be provided so that this economy could be realized.

5. The use of calcium chloride has a tendency to cause the surface to pit and become rough, which slightly increases the cost of blade maintenance above that of a similar road on which calcium chloride is not used.

6. It appears that a light oil such as that applied on section E can be used on a gravel road even under a traffic of 1,500 vehicles per day, in case there is a sufficient amount of loose material on the surface to absorb at least 75 per cent of the oil.

7. Where the light oil as applied on Section E is applied in a greater quantity than the loose material will absorb, it forms a thin glazed surface on the compacted portion of the road and the loose material which is quickly swept from the road cannot be successfully replaced as there is no tendency for material returned to the surface to adhere and become incorporated in the surface.

8. It is impossible, as yet, to standardize the use of light oil as a dust palliative for Michigan gravel roads because of the necessarily exact relation that should exist between the amount of oil applied and the amount of loose material. In no case should more than ⅛ gal. per sq. yd. be applied and the amount should vary with the amount of loose material on the surface.

9. The heavier bituminous materials used such as were applied on Sections A, C, D, F, G and H cannot be used for a dust preventive on Michigan gravel roads except as a material for forming a bituminous surface.

10. Regardless of the material used, a successful bituminous surface cannot be formed on a gravel road unless there is first a firm, even, hard surface on the gravel road which is free from loose material.

11. Bituminous surfaces formed within the limits of conclusion 10 and with the materials and amounts used in these tests, do not disappear uniformly.

12. It appears that bituminous treatments made without top dressing and expected to disappear annually, although apparently satisfactory during the summer months when used on a high type gravel surface, will leave the road in such shape that succeeding treatments will be impracticable unless the roadway surface is reconstructed, and furthermore will impair the quality of the surface if it is to be maintained thereafter as an untreated gravel road.

Further experimentation on calcium chloride work in Michigan and a study of its extensive use during the 1922 season, when the State Department contracted for 6,000 tons, has led to the conclusion that it will usually require three treatments to keep a road dustless throughout a season. The first application, ¾ to 1 lb. per sq. yd., is made as soon as the road becomes dusty in the spring, and additional applications of about ½ lb. per sq. yd. are made as it is required throughout the season. Where three such applications are made the annual cost will be approximately 3 cts per sq. yd, or about $320 per mile for an 18 ft. road.

The foregoing paper was presented at Road School recently held at Purdue University.

PROGRESSIVE CONSTRUCTION OF HIGHWAYS IN NORTH CAROLINA

By Charles M. Upham, State Highway Engineer, Raleigh, N. C.

If a state had an unlimited supply of money it would be a simple problem to

construct a state highway system, but practically all states are limited in the amount of money they have to spend in the construction of their road systems.

The function of a State Highway Commission is to provide a means of transportation for the state, and not the mere building of a few miles of hard surface roads and bridges at a few selected places throughout the state. For a state to develop as a whole, it is necessary that a connected system of highways should be available for the purpose of providing a means of transportation for the state's development.

Traffic is concerned with the roadway only to the extent of being provided with a smooth highway over which it may travel at a minimum of operation cost. The selection of the type of highway to construct is the problem of the engineer, after due consideration of all affecting elements, and should be a highway which will adequately and efficiently carry the traffic at a minimum maintenance expense.

It is absolutely essential that the road should be selected and so constructed that the money invested in the system of highways will at all times be a minimum. To best do this, means the construction of progressive type roads, in which all the standards of construction are the same, and by the use of which the lighter traffic is provided with a road suitable to its needs, and the heavier traffic with a hard surface road, which is the ultimate surface of all progressive type roads.

The solution of providing a means for traffic or the construction of a highway system in every state necessarily depends upon the local conditions in that state, and consequently, the method of solution will be different in the different states and depends on the economic, industrial, and social conditions throughout the state.

Practically every state in the Union has its cities and counties of high and intensive development, as well as its sparsely developed sections. To build immediately a system of hard surface roads throughout an entire state, when the demands for such roads are only within the highly developed sections, would be money wantonly wasted.

Within the highly developed sections, no doubt the construction of a hard surface pavement is the correct and only answer. In the urban and outlying districts, where the traffic is less intense, a lighter and less expensive road should be located, graded and drained upon the same standards customary with hard surface construction, so that when the country, through which the road passes, develops to the extent that traffic requires a heavy duty road, there will only be the necessity of adding the hard surface in order adequately to provide for the heavy traffic which may at some future time make demands on this highway. Still farther from the highly developed centers, and far out into the less developed country, there are still lesser traffic demands. Few vehicles and light loads generally constitute the pioneers in transportation. Quite often graded roads, with the proper drainage structures, constructed upon hard surface standards, will suitably take care of this rural traffic.

After the construction of the graded road provides a means to development, and the traffic demands become greater, a higher type surface, possibly a sand-clay, topsoil or gravel, can be added to the previously graded road, and when the locality still grows and the sections become more highly developed and the traffic demands are greater, there only remains for the road builder to surface these progressive roads with a hard surface. This will efficiently provide for the heavy traffic, which ultimately makes demands on the roads in the developed localities.

North Carolina has three distinct geographical divisions. The mountain section is made up of farming and mining sections with numerous resorts so located as to take advantage of the wonderful scenery; the piedmont section or foothills, with its farms and industries highly developed; and the flat coastal plain, with its excellent farms and industries claiming great attention for their transportation needs. These three great geographical divisions are divided into 100 counties, and many more centers of population. It is the work of the State Highway Commission to connect these centers with a highway system or a means of transportation which will adequately provide for the class of traffic which now exists and is expected in the near future. The problem of selecting the type of progressive road is somewhat reduced when it is seen that hard surface roads are immediately required efficiently and economically to care for traffic demands in connecting the developed industrial centers. This is also true in the highly developed farming sections. The remainder of the problem is to provide suitable and continuous roads to connect up the cen-

ters in a manner which will satisfactorily provide for the needs of transportation, at the same time keeping the money investment always at a minimum.

The distances are long and it is practically always the fact that the state's development and the intensity of traffic will not justify the construction of hard surface roads throughout the entire system. The answer to the problem of providing the state with a means of transportation lies in the construction of progressive type roads so constructed on high standards that they may be ultimately turned into hard surface roads by the addition of a higher type standard surface.

The North Carolina method of progressive type construction is to grade the road, using the same standards for line and grade that are used in hard surface construction. Only one standard of drainage structures is used regardless of whether the road is merely graded or is to be covered with a hard surface. This construction of graded road will care for the light traffic which generally exists in all newly developed localities. This graded road is at all times maintained and when the increased traffic creates a high cost of maintenance, then it is indicated that it is time to construct the next higher type of road surface. The next step in the progressive type road is to cover the graded road with a selected soil material, such as sand-clay, topsoil or gravel. This material is generally of higher bearing value than the natural soil, and is a material which is less affected by moisture and therefore more suitable for use as a road surface. This selected surface material is maintained as a subgrade highway until such time as the maintenance cost becomes excessive and the increased traffic indicates that a hard surface roadway is necessary.

The cost of grading and the drainage structures generally constitutes about one-sixth of the ultimate cost of a hard surface road. To add a selected soil surface adds very little difference to the cost of this construction; consequently about six times as much road, with a selected soil surface, may be constructetd for the same money as though the money was spent for the immediate construction of hard surface roads. This makes it possible for transportation to be benefited to a much greater extent and the state to develop at six points rather than in one.

It will be noted that the construction of the selected soil surface is an addition to the graded road, and no previous step in the grading or construction of drainage structures has been lost or thrown away in the construction of this selected soil surface road.

In the progressive type road all steps taken in its construction include the utilization of all previous construction when transforming the road to the next higher type, and each step may be considered as a subgrade for the next higher type surface. This in itself justifies the expenditure of a sufficient amount of money to select soils of a character which may, with proper maintenance, be used as a surface material until such a time as traffic demands, or the cost of maintenance makes it necessary to construct the next higher type of hard surface. By this method of contruction the graded road or the selected soil surface can truly be called a subgrade highway, and is often the economic solution for road construction over a large portion of a state system.

The ultimate step in progressive type construction is the addition of the hard surface. After the maintenance on the selected soil surface becomes excessive or when the country and traffic develop to the extent that a hard surface road is necessary, the next step is to construct the hard surface pavement directly on the selected soil surface. This method of progressive construction utilizes advantageously the selected soil surface as a stabilized subgrade for the hard surface pavement, and on account of the complete settlement, and on account of the character of the selected soil surface, the subgrade is stabilized sufficiently to aid the hard surface in carrying the loads.

Therefore it may be seen that the construction of the progressive type road, light traffic or a small tonnage is cared for by a graded road of comparatively low cost. As the traffic demands and tonnage increases, the road is increased in strength, and the increase of the investment is justified. As the traffic and tonnage increase to the maximum, a hard surface road is constructed. The construction of roads on progressive principles means that the greatest percentage of the invested money is in permanent construction, and justifies the expenditure of bond money in any progressive type road.

North Carolina has constructed many progressive type roads, It has already completed its cycle by placing hard surfaces on roads which were previously graded and stabilized with a selected soil

material, although at present it has a reasonable mileage of graded roads in the newly developed localities; it is maintaining as subgrade highways a large mileage of selected soil roads and thus affording a means of traffic to a great portion of the state. The completion of about 400 miles of hard surface construction in 1922, many miles of which was hard surface, added to progressive type roads, demonstrates the complete and satisfactory manner in which the progressive type road is caring for the traffic in North Carolina and shows that this method of road construction is no longer in the experimental stage, but that this means of constructing a highway system is economically and practically sound and is highly recommended where the geographical, industrial, social and economic conditions are as found in North Carolina.

The foregoing paper by Mr. Upham was presented at the recent annual meeting of the American Road Builders' Association.

PROBLEMS IN HIGHWAY BRIDGE ECONOMICS

By Lewis M. Gram, Professor of Structural Engineering, University of Michigan, Ann Arbor, Mich.

The function of an engineer in construction work is to solve his problems so that adequate service will be rendered at minimum cost. This is a basic principle easy to state, but difficult to carry out with any degree of uniformity, because just what constitutes "adequate service at minimum cost" is a matter of judgment, which in turn involves differences of opinion. Furthermore, engineering problems relating to highway bridges cannot be entirely disconnected from similar problems relating to the adjacent roadway. The best solution of a bridge problem might not be so for the adjacent roadway, and vice versa. The effect of each upon the other in particular cases should be carefully considered, and to a certain extent it is one problem instead of two, having in mind the best interests of the highway as a whole.

Permanency of Structure

Obviously the study of all highway bridge problems from a broad economic viewpoint involves the probable permanency of the structure; and it is to that particular phase of the subject that this discussion will relate. Again, it must be remembered that bridges are integral parts of the highway, and as such the extent of their future usefulness is subject to the same uncertainties that surround our highway transportational facilities in general. Difficult, however, as it may be to forecast all of the conditions affecting the useful life period of the roadway portions of a highway system, there are many reasons why the problem relating to bridges is even more complex. From their very nature bridges have to perform a two-fold service, that which is incidental to the passage underneath, as well as that which is required by the traffic over them. Hence radical changes in either respect from the conditions for which any particular structure was designed will affect the useful life period of the bridge. Although a fixed bridge, by which is meant one that has no moving mechanism, does not wear out to any greater extent than the roadway surface which represents a small cost compared to that of the bridge as a whole, the materials in the bridge proper may disintegrate more rapidly than those in the roadway. Repairs or reconstruction may be long deferred in a roadway while weak spots in a bridge require immediate attention.

Useful Life Period

As a purely business proposition the probable permanency of a structure is a question that should be taken into account, together with that of initial cost. It would be poor policy indeed to buy a structure of low original cost, but which required expensive repairs soon after its completion, or which would have to be replaced at a comparatively early date. Unfortunately, however, the useful life period of a structure involves so many uncertainties that it cannot be definitely anticipated. Perhaps the best we can do is to base our judgment of the future upon the past, although the disappointing thing about such a procedure has been to find, as each year's developments passed into history, that our most liberal expectations for that particular period have been far exceeded. In the light of historical data the outstanding factors affecting the useful life period of a bridge are:

First—The relation between the capacity for which the structure is designed and that which may later be required.

Second—The deterioration of materials of which the structure is built.

Other circumstances affecting the permanency of bridges, such as relocation of a section of highway or radical change in profile for the purpose of reducing grades, do not fall within the intended scope of this discussion. Unfortunately from the standpoint of attractiveness of our public

structures, the appearance of a bridge has little influence upon its permanency, and a structure unsightly when built must be endured until for some more practical reason it is discarded.

Capacity

With reference to capacity, the life period of the structure can be partially controlled by the designer depending upon how liberally he provides for future requirements. Just what might be considered reasonable liberality in the matter of future increases in traffic, however, is clearly a matter of opinion, and it is not unlikely that designs based upon them will fall as wide of the mark in the future as in the past. For the purpose not of offering an explanation for the inexcusable lack of foresight on the part of the designers in special cases, but rather to demonstrate what little chance a real prophet of a decade ago would have had in convincing the average road commissioners of the accuracy of his vision regarding highway usage, some statistics relating to the growth in volume of highway transportation are pertinent. The registration of motor vehicles in the United States, by which is meant both passenger cars and motor trucks, increased from 1,033,096 in 1912 to 10,448,632 in 1921, or over 1,000 per cent; the registration of vehicles in two states alone in 1921, namely, New York and Michigan, exceeded by 222,700 the total registration in the United States in 1912; and the increase in registration of 1921 over 1920 in the United States, despite a poor year for motor vehicle production, also exceeded the total number of vehicles in 1912. With these facts before us, it is no wonder that many bridges constructed ten years ago with allowances for future increases in traffic, which were then considered reasonable by the designer, are inadequate today. The surprising thing about it is that so many bridges have survived. A comparison of the volume of motor traffic of today with that of twenty years ago shows an even more startling development. Because of lack of registration we do not have at hand accurate figures regarding the number of vehicles for that early period, but such production records as are available indicate practically no motor trucks and less than 5,000 passenger cars.

Volume and Weight of Traffic.

To add to the difficulty of making the roadway fit the traffic, motor vehicles are unlimited in their field of action. Unlike the structures of a railway, which are designed to meet the needs on particular systems, the highways are public and may be used by whoever desires to do so. Scientists tell us that certain insects which multiply with slightly greater rapidity than motor vehicles, do not wander far from their place of birth. It is not so with motor vehicles. We in Ann Arbor are accustomed to see quite a sprinkling of vehicles from foreign states, occasionally as remote as Florida and California. A good road to an objective point, however distant, advertises itself with remarkably prompt and voluminous results. All of which adds further to the uncertainty of just what the future requirements in any particular locality will be.

Furthermore, the above statistics refer to increases in volume of traffic, which is only half the story, as the capacity of a highway may be expressed in terms of either volume or weight of traffic. In passing, it might be noted that inadequacy of bridges with respect to volume of traffic has been more acute in recent years than with respect to weight. This is explained by the fact that the margin of excess usually provided in the design of highway bridges is greater for weight than for volume of traffic. A two-way structure is never more than that, while increases in service loads are always permissible in properly designed structures. In some respects this is a fortunate situation, inasmuch as inadequate volume capacity of a structure means simply throttled traffic involving moderate danger and delay, while failure under excessive load may result in fatalities and prolonged tie-up of miles of a highway system.

While the story of motor transportation reads almost like a fairy tale, it has its parallel in what has been done in a corresponding period in the development of good roads. In fact, it is impossible to estimate the extent to which each has contributed respectively to cause and effect. The users of motor cars are numerous and influential enough to bring about road improvement. Road improvement in turn stimulates the use of motor vehicles, and thus we have the one always chasing the other in an endless cycle, as it were. Just when one will catch up to the other is of course impossible to tell, but naturally road improvement and motor car production will go hand in hand with abnormal speed until traffic on the highways reaches its economic level in the whole field of transportation.

As an important detail in the process

of road development, to which reference has been made, highway bridges have occupied a peculiar economic position. Per foot of highway the average bridge is a comparatively expensive part of highway construction. Naturally, therefore, the cost of bridges is always reduced to a minimum consistent with service requirements. In the days of horse-drawn vehicles a country bridge was considered of ample volume capacity if wide enough for two ordinary vehicles to pass at slow speed, or say a minimum of 14 ft., and high enough, if there was overhead construction, to permit the passing through of a load of hay or a threshing machine. If perchance two vehicles should meet at a bridge and one be required to wait until the other one had passed over, the value of time in transit was not sufficiently great even to cause serious mental irritation. Nowadays the situation is vastly different. With the advent of swiftly moving vehicles, transit time has taken on new standards eof value and traffic interruptions are more serious. The loss of time thereby may have real or fancied value, but in either case pressure is properly brought to bear to remove the throttle.

Aside from the more or less serious delays referred to, there are other good reasons which tend to terminate the usefulness of many structures long before the materials with which they are constructed have dangerously deteriorated. A bridge which is inadequate with respect to volume of traffic is likely to be a real menace to rapid highway transit, in that it contributes to many accidents either by collision with portions of the structure which project above the roadway, precipitation over high banks or both. It must be borne in mind that many drivers of highway vehicles are unfamiliar with the roads over which they are traveling, and it goes without saying that in the interest of safety to the general public every reasonable precaution should be taken to minimize hazards.

The Waterway

Another feature of inadequancy in the design of bridges, often resulting in serious damage and sometimes to the extent of complete failure, is with respect to the waterway. Major defects, such as scant opening for the flow under flood conditions or shallow bearing on the soil, will directly endanger the piers and abutments; and stability of the superstructure being dependent of course upon that of the substructure, it is doubly important that every detail of the foundations be carefully studied and liberally designed.

In discussing the permanency of bridges from the standpoint of deterioration of the materials of which they are constructed, we are standing on firmer ground. That is to say, the situation is not complexed by such uncontrollable factors as the development of vehicular traffic. The useful life period of a bridge, insofar as the materials are concerned, is largely dependent, first, upon the kinds of materials used in construction and, second, upon the places where used and the care which is given in maintenance.

Life of Timber

As a matter of common knowledge for example, timber when alternately wet and dry will decay in a few years, and the only way to preserve it indefinitely is to keep it in either one condition or the other all the time. Practically it is easier to keep timber saturated with water than perfectly dry and in substructure work sound timber, which is always submerged in fresh water, may be considered absolutely permanent. Samples taken from the timber in the substructure of the Belle Isle bridge, after about 30 years' submersion, showed absolutely no deterioration. Other similar observances are on record. The critical zone for timber in substructure work is adjacent to the water line, where the material is naturally subjected to alternately wet and dry conditions. Timber piles and grillages, as frequently used in the foundations for bridges, bear silent witness to that fact.

It is practically impossible on the other hand to prevent timber which is used in the superstructure of bridges from being wet or dry intermittently. Paint and various impregnating processes will go a long way toward preservation, although sooner or later decay is likely to get started at inaccessible joints. Complete housing is the only effective way to make the timber superstructure of a bridge reasonably permanent, but this is obviously an expensive expedient in the matter of first cost, as well as in maintenance of the housing itself. The average lifetime of timber bridges, insofar as the decay of the material in the superstructure is concerned, may be estimated at from 12 to 15 years when exposed to the weather, notwithstanding the fact that in some cases they have been continued in service by careful maintenance for over 50 years. When thoroughly protected from the

weather by housing, timber bridges may last indefinitely with comparatively inexpensive maintenance costs on the bridge proper. There are in fact examples of enclosed timber structures built nearly a century ago which are still in service, to the discredit of so-called "permanent" bridges in their immediate vicinity. Danger of complete destruction by fire is always a hazard which cannot be avoided in a timber structure, and unquestionably this fact had much to do with causing metal structures to become popular long before they compared favorably with timber bridges in the matter of cost.

Life of Metal Bridges

Steel and wrought iron bridges would be absolutely permanent with respect to deterioration of materials if, as in the case also of timber bridges, the conditions to which they were exposed were ideal. Steel and iron, however, will slowly decay through oxidation or rusting whenever they come directly in contact with air and moisture. This action is sometimes referred to as a slow fire. Various chemicals and gases and stray electric currents tend to accelerate the oxidation. When submerged in water the rusting process progresses more slowly, depending upon the extent to which the water is aerated. The best way, therefore, of guarding deterioration of steel and iron in our bridges is to prevent direct contact with air and moisture; and a film of paint is usually employed for that purpose. The practical difficulties in the way of perfect protection to the metal in a bridge by such method, however, are well known to those who are familiar with maintenance problems. Even though paint is applied at reasonably frequent intervals, there are many inaccessible places where decay is inevitable and cannot be checked. Under ordinary conditions of exposure the most vulnerable points for the disintegrating influences are at pin and riveted connections.

With reasonable care in maintenance, however, the materials in a metal bridge are likely to be in serviceable condition when the structure has outlived its usefulness in any particular locality for other reasons. Wrought iron is less susceptible to corrosive action than steel, and as evidence of the durability of wrought iron bridges, there is an arch bridge of that material built in 1835, near Pittsburgh, which is still in service and in excellent condition from a corrosive resistance standpoint.

Strange to say, there are cases on record where metal bridges have been completely destroyed as a result of fire in the wooden floor or paving. In 1915 nine through spans and half of the draw span of the old Belle Isle bridge in Detroit were completely destroyed in that manner almost before the fire apparatus could arrive on the scene.

Useful Life of Concrete Bridges

Concrete and reinforced concrete is popularly conceived to be an absolutely permanent material without maintenance, but an examination of many existing concrete bridges or other outdoor concrete structures will demonstrate that such an impression is not unqualifiedly true. For various reasons which will not be referred to here except to say that sometimes they are decidedly obscure, concrete as placed in our bridges has a wide range in quality, and if in speaking of the absolute permanency of concrete, material properly designed, carefully mixed and placed is meant, the statement is doubtless warranted. If on the other hand the material is defective, either with respect to design or fabrication, it will fall far short of absolute permanency. As well expressed by Professor McKibben, the owner of a concrete structure should not be led to believe that in every case he will have something as enduring as Verdi's "Il Trovatore," or Dante's "Divine Commedia." Many outdoor concrete structures do in fact show positive deterioration after 5, 10 or 15 years of exposure. There is especial danger when moisture can reach steel reinforcement as the formation of rust sets up a tremendous pressure and usually results in spalling off of the surrounding concrete. It is only fair to add in behalf of good concrete as a bridge material that it will increase in strength as it ages. The ultimate strength in compression at the end of a year is about 50 per cent higher than at 30 days, when it should have ample strength to develop the stresses assumed in design. Furthermore, the weight of a concrete structure is so great in proportion to that of the traffic that large increases in weight will have a relatively small influence upon the intensities of stresses in the concrete. These facts are of distinct advantage for concrete, considering the future weight adequacy of structures in which it is used.

Summary

The factors which have to do with the useful life period of any particular structure may be broadly summarized into three points:

First—Materials.
Second—Design.
Third—Maintenance.

There are proper places in highway bridge construction for the use of each of the three kinds of materials herein discussed—timber, steel and concrete. Their advantages and disadvantages respectively are well known through observation and experimental investigations, and with data at hand relative to comparative prices the designer is enabled to make a choice which will properly meet the requirements in any particular case.

Under design is the presumption that the materials, regardless of kind, will be economically and yet wisely proportioned. Full consideration should be given to the historical fact that inadequacy, either with respect to volume or weight of traffic, rather than deterioration of materials of construction, has been the prevailing cause of premature abandonment of highway structures. The designer should always keep in mind the probability of required strengthening, or expansion of a structure before the materials have outlived their usefulness. Details especially should be liberally proportioned. Comparatively little expense may be added by excess material at critical points, and yet minor weaknesses may develop into a case of the tail wagging the dog in the matter of prolonged serviceability of the structure as a whole. The general type of structure selected has an important bearing on the practicability of volume expansion, in case the growth of traffic requires either a new bridge or an increase in width of the old one. If any structural portions of a bridge extend above the roadway it is in general impracticable to adopt the latter expedient, while a deck structure can usually be extended indefinitely in a lateral direction without interfering with a clear roadway. The deck arch type is particularly advantageous because of its expansiveness as well as appearance, and because of the temptation to use it quite generally for highway bridges, a word of caution should be expressed, that is to make sure that the foundation conditions, which have so much to do with the integrity of the arch type, are favorable for it.

In the final analysis the useful life period of a bridge, insofar as it may be affected by decay of the materials, depends upon maintenance and repair. Careful and systematic inspection, followed up by prompt attention to such defects as may appear from time to time, is bound to result in prolonging the life of a bridge, whatever the materials of construction may be. Private corporations, and especially railway companies, are keenly sensitive to the value of thorough maintenance, probably for the reason that the benefits of longer structural life and uninterrupted service show up in the dividends. It is a notable fact that most steel and iron railway bridges replaced by reason of inadequate capacity are practically as good as new, insofar as the materials are concerned. Highway bridges, on the other hand, are too often sadly neglected, painting too long deferred, shoe pockets allowed to fill up with dirt and vegetable matter, with the inevitable result that the life of many structures is unduly shortened. For reasons pointed out there are some elements in the design of highway bridges which are pardonably misjudged, but there is absolutely no good excuse for careless inspection and maintenance. Whatever materials may be used in constructing a bridge, and whatever volume and weight of traffic it may have been designed to carry, there is no better and certainly no cheaper elixir of life than reasonable care and attention.

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DEVELOPMENTS IN BITUMINOUS PAVEMENT MAINTENANCE

By B. C. Tiney, Assistant Maintenance Engineer, Michigan State Highway Department, Lansing, Mich.

Although strict adherence to my subject would confine this discussion to bituminous pavements, I have included waterbound macadam, as this is a type of surface upon which bituminous materials are used extensively in maintenance.

Between 1½ and 2 million gal. of tar and asphalt are used annually for the maintenance of roads in Michigan. Approximately 85 per cent of this is applied as a surface treatment on water-bound and bituminous macadam roads.

Motor Pressure Distributors

Modern mechanical devices for preparing these surfaces for treatment and for spreading stone chips upon the surfaces, have been developed. Bituminous materials are quite generally applied by motor pressure distributors of various types. The pressure is usually afforded directly

by a pump, operated by a power take-off from the transmission of the truck or in a few instances, by a separate power plant. A powerful truck motor is required if it is to assume the additional work of pump operation. The pump is so designed that it can be used for filling the distributor from tank cars as well as applying material to the road surface. A cut-out may be so arranged that the exhaust from the motor comes in contact with the pump, and by warming the material, increases fluidity and ease of pumping.

It is important that distributors be equipped with heating arrangements. Even though the material is brought to the required temperature in the tank cars, a long haul or other delay will often necessitate re-heating on the road. Heating equipment may consist of oil-burners or steam coils. Steam is, in one type of distributor, generated by a small boiler on the rear of the truck, but it is more commonly supplied from an outside source, which is not always conveniently located. The advantage of a self-contained source of heat is obvious as it permits of heating during a long haul so that the material arrives on the road ready for application.

Spraying manifolds are so designed that any width of treatment from 2 to 16 ft. may be applied, but common practice confines the application to about 8 ft. or half the width of roadway, at one time, as this enables traffic to avoid the freshly laid material.

Distributors should be equipped with thermometer, pressure gauge, and speedometer. The tank should be calibrated in order that the correct gallonage may be charged to each road. The rate of application is varied by setting of valves and by the speed of the truck. A table showing the quantities applied per sq. yd. for different valve settings and truck speeds should be posted in the cab for use of operator.

Use of County Forces and Equipment

Until recently, the distributor service afforded by the bituminous materials companies has been largely employed by counties in this state. This service, while very commendable in some respects, had certain draw-backs. Many counties required service at the same time and the companies found it difficult to arrange a schedule which would give every road a treatment at the proper time. A macadam road, upon which a necessary treatment is deferred, soon begins to ravel and requires hand patching.

The work being widely scattered, required that distributors be moved long distances at considerable expense. The labor gangs employed by the companies to prepare surfaces and spread stone coverings, were compelled to remain idle at times, due to unfavorable weather conditions or delay in shipment of materials, and this increased the overhead cost to the companies.

It was believed that conditions might be bettered and the work placed upon a more economic basis if performed directly by use of county forces and equipment. With this in view, five counties purchased distributors in 1922. These machines were mounted on army trucks furnished through the State Highway Department at a nominal cost.

Analysis of Costs in One County

The plan has, in all cases, proven very satisfactory. The quality of work performed has been excellent, and a material saving in cost has been effected. An analysis of costs in one of these counties for the season of 1922 is as follows: Twenty-four roads, aggregating 408,000 sq. yds. were treated with 135,000 gals. of tar, averaging a little less than 1-3 gal. per sq. yd. Tar cost 9.4 cts. per gal. f. o. b. county in tank cars. Slag cover, costing $2.25 to $2.50 per ton f. o. b. cars in county was distributed in piles by motor trucks. Labor was 35 cts. per hour.

AVERAGE ITEMIZED COST PER SQUARE YARD

Slag, in piles along road	$0.016
....	0.031
Application of tar	0.005
Preparing surface and spreading slag	0.008
Tar f. o. b. railroad siding	
Gasoline, oil and overhead	0.006
Total cost per square yard	$0.066

A portion of this material was applied hot. The costs given include a rental charge on equipment used.

The contract price in this county in 1921 for a treatment of 1-3 gal. per sq. yd. was $0.113. On this basis we have a saving of $0.047 per sq. yd. on 408,000 sq. yds., or approximately $19,000. About $4,000 of this amount is due to a reduction in the price of tar, leaving a saving of $15,000 which is chargeable to the performance of work by use of county forces and equipment.

Similar results have been the experience of other counties operating their own distributors, and it is believed that

this plan will come into more general use. The installation of permanent tanks for storage of bituminous materials would add to the efficiency of the system. Demurrage and tank-car rental, which amount to considerable sums if weather conditions are unfavorable, would be practically eliminated. The shipment of material is likely to be, at best, an erratic proposition. Storage facilities would tend to co-ordinate shipment with application of material, enabling the work of distribution to proceed more steadily.

It is often possible to install storage tanks at such elevation as to permit of unloading from tank cars by gravity. Tanks should be of sufficient size to hold one carload (approximately 10,000 gals.) of material, and should be equipped with steam coils or other arrangements for heating.

Patching

In addition to regular surface treatments at intervals of from one to three years, depending upon the amount of traffic, it is neccessary that bituminous macadam surfaces be patrolled frequently and small holes patched soon after they appear. The importance of this feature of the work is usually under-rated, but it is one of the answers to successful maintenance. Shallow breaks in the surface crust may be swept clean, given a brush coat of bituminous surfacing material and covered with a layer of stone chips. A brush coat is preferable to a poured treatment as it avoids an excess of material, which is very undesirable. The practice of patching holes greater than ½ to ¾ in. in depth by pouring partly full of a cold bituminous surfacing material and covering with an excess of chips, has been quite common and is to be discouraged. It is obvious that such patches will remain unstable for some time and a large per cent of them will be displaced by traffic. Patrol maintenance on shallow patches may be conveniently handled by storing bituminous surfacing material in barrels sunk in the ground at intervals along the road. These barrels are provided with covers and are readily filled by a hose from the distributor tank. Piles of stone chips are also stored at necessary intervals. A patrolman equipped with a wheelbarrow, bucket, broom and shovel is enabled to patrol a maintenance section very efficiently.

Holes of an inch or more in depth may be conveniently repaired by the cold patch method, being tamped full of a cold mixture of aggregate with cut-back tar or asphalt, which depends for its setting-up qualities, upon the evaporation of volatile oils.

The stone for this mixture may range in size from ¼ to ¾ in., fractured shapes being preferable to rounded pebbles. The quality of the aggregate is a large factor in the success of any bituminous mixture, and it is often found to be economy to ship in a hard tough stone at additional cost, rather than use a cheaper local material of inferior quality.

The mixture should be made in the proportion of 16 or 18 gals. of bituminous material to a cubic yard of stone. A small amount of coarse sand may be added, but is not essential to good results. An excess of either sand or bituminous material will tend to make the patch unstable.

It is found that the patches offer more resistance to displacement by traffic if the mixture is allowed to cure for a few days before placing in the road, and also, in case of the deeper holes, if a larger stone is used in the bottom layer of the patch, being surfaced with the finer mixture. The hole to be patched should be swept clean and painted lightly with bituminous material before tamping in the mixture. A light sanding of the surface prevents adhesion to traffic while curing.

Mixing Stations

Where considerable quantities of cold-patch are used, the mixing is most efficiently performed by means of a small concrete mixer. This may be housed in a building of sufficient size to provide space for mixing and storage of materials. The design of the building should be such that a motor-truck may be driven into it and at least a part of the materials handled mechanically.

A number of such mixing stations placed at central locations for given maintenance sections, could be constructed on standard plans, so that one mixer could be readily moved by truck and made to do service for all stations. In this way a supply of mixture might be kept on hand and curing at each station.

A hundred miles of bituminous surfaced road, for example, might be divided into four 25-mile sections, each having a central mixing station so that the average haul of mixed material would be only 6 or 7 miles. This condition would, of course be ideal, the work being, in general, more scattered, but it is believed that in most cases a satisfactory arrangement could be worked out. Such a system has been in practice in Lucas County, Ohio, for the

past 5 or 6 years and has proven very efficient. The mixing stations here are used also for storage of equipment and as headquarters for other kinds of maintenance work.

Using Bituminous Macadam

Extensive replacements of bituminous surfaces are often made with bituminous macadam, by the penetration method. Two sections of a certain trunk-line of this state have, within the past four years, furnished notable examples of road failures. They were quite widely separated, but had many characteristics in common, the construction of both being a Topeka surface on a cement-concrete base. The failures were caused by a combination of heavy traffic, poorly-drained subgrade, and insufficient thickness of base. The maintenance of these roads presented a difficult problem. Both were main arteries, carrying an average daily traffic of 2,500 to 4,000 vehicles, many of which were heavily loaded trucks, and it was imperative that extensive replacements be made with as little inconvenience to traffic as possible.

This consideration led to the choice of bituminous macadam for replacement, as these patches could be placed under traffic almost as soon as they were finished. The general method of procedure was to remove sections of the broken pavement and the subgrade to a depth of at least 11 ins. below finished grade, or deeper if necessary to obtain a firm foundation for the new work. It was often found necessary to go to a depth of 18 to 24 ins. The lower portion of the patch was constructed of macadam in 4-in. layers, compacted by a roller, if the patch was large enough to permit a roller to work, otherwise being hand-tamped. In the case of some of the larger patches, the upper layer of this macadam base was waterbound, but in most instances it was merely dry-filled with screenings. The surface course of bituminous macadam was then placed to such height that it rolled down flush with the finished grade of the old pavement. None of these patches has ever failed under traffic, some having been in place for three years, being given surface treatment maintenance.

This work is rather expensive, costing from $5 to $7 per sqare yard, but the conditions were abnormal, and any type of replacement would have been very costly. Had it been possible to have closed the roads to traffic, a saving of at least 25 per cent would have been effected. It is thought that these roads may, ultimately, be rebuilt with a heavy macadam base and a high-type surface, in which event many of the large patches will have a salvage value. In fact, 4½ miles of one section has been reconstructed, using a three-course water-bound macadam, 12 to 15 ins. thick, which is at present carrying traffic on a surface treatment. The idea in this case is to let the macadam season under traffic for a time before placing a high-type surface.

Maintaining Asphaltic Concrete and Sheet Asphalt

The maintenance of asphaltic concrete or sheet asphalt surfaces in locations where an asphalt plant is not accessible is often carried on by the use of small portable plants wherein the asphalt and aggregate are heated in separate compartments and the mixing is done by hand. A gang of four men using one of these plants can mix and lay from 30 to 60 sq. yds. of surface daily. A roller is not required on these small patches, as they may be compressed by hand-tamping with hot irons.

In relieving ruts and depressions in an old asphaltic pavement by the addition of fresh mixture, the new material may be bonded to the old by first softening the latter with a surface heater. The heat is applied by oil-burners and confined to the pavement by a hood. Care must be taken to avoid burning the old material, although no flame comes in contact with it.

Using Old Asphalt

Old material taken from an asphaltic pavement may sometimes be re-heated and used again. This plan is used a great deal in the winter maintenance of asphaltic streets in the city of Cincinnati. The old pavement is broken into pieces about 2½ ins. in size and placed in four-wheeled kettles of 100 gals. capacity. About 4 or 5 gals. of water are added, the kettle is covered and the mixture allowed to steam for about one-half hour. The material is then turned over with heavy bars and spaded. Allowing time to steam, the mixture is turned and spaded several times until the water is all evaporated and the temperature raised to about 325 deg. F. The kettles are then hauled to the street and the mixture tamped into the holes.

Central Purchasing

Prior to 1922 the bituminous materials used for maintenance of state and county roads in Michigan were purchased individually by counties under the trade names of the various producers. The State Highway Department, in participat-

ing in the cost of trunk line maintenance, found but little uniformity in the price or quality of materials used for the same purpose in different counties.

In 1922 the state introduced the idea of centralized purchase of these materials on standard specifications. Acting in behalf of counties, the state received competitive bids on estimated quantities. A tabulation of all bids was sent to each county, together with recommendations as to choice of materials. The counties then executed contracts on standard forms furnished by the department. Arrangements were made for laboratory control of the materials by the State Highway Testing Laboratory. This plan resulted in a material reduction in price, more uniform quality of materials and better service. The state and counties are unanimous in their desire to continue this arrangement, with a few minor changes in 1923.

Use of Tars

Specifications used for tars for surface treatment were those published by the A. S. T. M. in their Tentative Standards of 1921. These embrace four different specifications covering high and low carbon tars for both hot and cold application. Practice in this country has not established any decided preference for either high or low carbon tars. In England the refining of tars for road work dates back to 1834, and at a recent conference of engineers in that country, high carbon tars were much favored on the ground that the presence of approximately 25 per cent of free carbon rendered the tar more viscous and less susceptible to temperature changes. On the other hand, there is good reason to believe that carbon, being an inert material, simply dilutes the tar and reduces its cementing value. The fact remains that good results have been obtained in this state with both high and low carbon tars.

Cold application tars are generally preferred for surface treatment work in Michigan, but the practice of heating these slightly to facilitate application is becoming more common, especially if a very light treatment is desired.

Specifications used for surface treatment asphalts were those published by the United States Bureau of Public Roads in their Bulletin 691, under designation of OH-1 and OC-2. These provide materials for both hot and cold application. Our general observation has been that better results may be obtained with the cold application asphalts by heating them slightly. The tendency with the hot application materials, unless carefully handled, is to produce a heavy mat which will push under traffic. If laid on new work they should be preceded by a priming coat of lighter material.

Standard specifications of the Michigan State Highway Department covered materials for bituminous macadam. Companies were asked to bid on their own specifications for cold-patch and joint-filler, but a lack of uniformity in these materials has led to the adoption of standard specifications for both tars and asphalts for 1923.

The foregoing paper was presented at the Ninth Annual Michigan Conference on Highway Engineering at the University of Michigan.

FIVE YEARS EXPERIENCE WITH PATROL MAINTENANCE IN WISCONSIN

By J. T. Donaghey, Maintenance Engineer, Wisconsin Highway Commission, Madison, Wis.

Conditions existing in Wisconsin prior to April 1, 1918, were similar, I believe, to those existing in a majority of the Middle-Western and Western States at that time. Under the provisions of various laws, individual roads had been constructed and a very small amount of maintenance work had been done, and what had been done was entirely unsystematic. We had built to that date under our state aid and county aid laws approximately 3,375 miles of surfaced roads and 2,800 miles of unsurfaced roads, but no effective provisions were made for their maintenance. In a very few instances proper maintenance had been provided, but in a majority of cases the roads were permitted to deteriorate rapidly.

Prior to the enactment of the law providing for maintenance of the State Trunk Highway System, our department had made quite thorough investigations in our own state and in neighboring states of the most practical and satisfactory method of maintenance of both surfaced and unsurfaced roads, and especially the most practical methods of improving ordinary town roads where nothing more than ordinary township road work had been done. From these investigations and from our years of experience dealing with the local town boards and the county boards of the state, we believed it possible, practical and economical to install a patrol main-

tenance system on a large state trunk highway mileage.

We were satisfied that many miles of the unimproved town roads could be transformed into reasonably good roads, for light traffic at least, at a very small cost, providing ordinary intelligence and proper equipment were used, and that in so doing we would be serving the people of the state of Wisconsin much better than by building each year a few more miles of high type surfacing.

Wisconsin has 78,000 miles of all classes of highways. At the time of taking over the maintenance in the spring of 1918, our records show that 255 miles were concrete; 1,775 miles stone macadam; 15,670 miles gravel, most of which was ordinary town work; and 60,300 miles earth. We believed that a system containing not less than 10 per cent of the total road mileage of the state would be required to serve traffic reasonably well, and that eventually the public would demand that not less than 20 per cent of the total road mileage be adequately maintained. However, we felt that the maintenance of a 20 per cent system was many, many years in the future.

In the construction of a large mileage of different types of road under the state aid and county aid laws before mentioned, the county was the unit doing the work. At the same time the work was performed under the plans, supervision and direction of the Highway Commission. This plan developed a construction organization in every county and also resulted in a large amount of road building equipment being purchased by each county. The counties were expending quite large sums of money for that time, practically all of which was force account work and they were probably getting more for their money than if the work had been done by contract, due in a great measure to the fact that appropriations were not large. Improvements were originated in more than 50 per cent of the instances by township votes. Therefore, the projects in the early days seldom exceeded $3,000 to $5,000 which was expended in a majority of cases on grading and culverting and lower types of surfacing.

Maintenance Plan

In discussing the future maintenance —of a large state trunk highway system before the legislature of 1917, the question arose as to whether the state should maintain the entire system with a state organization, the state paying the entire cost, or whether the actual maintenance work should be done by each county and the county be reimbursed by the state after the work was satisfactorily performed. There were many advocates for each plan. After analyzing the two plans thoroughly, we arrived at the following conclusions.

Under the state maintenance plan it could readily be seen that:

(1) The Highway Department would have closer control of the entire maintenance operations.

(2) The work done might be better and more economically done and in many instances done more promptly.

(3) The costs of the work would be more accurately kept and unit costs of work could be shown on many specific parts of the work which would be of considerable value on other similar work in the state.

On the other hand, it could readily be seen that:

(1) It would require an appropriation sufficient to purchase approximately $2,000,000 worth of necessary maintenance equipment. This appropriation would have been very difficult, if not impossible to obtain from the legislature at that time.

(2) It would require an organization of experienced maintenance men that would be difficult to procure without employing the very men who were employed on road work by the several counties.

(3) It would result, in many instances, in the operation of a state road maintenance crew in close proximity to a county road crew, which would be undesirable, as our laws permit state employes to work but eight hours per day while county forces may work ten hours.

(4) There would be no incentive other than the example of good maintenance shown by state work to induce the local communities to maintain other roads not a part of the State Trunk System.

(5) Criticism of our work as a state organization would come from the other side of the road fence, which in many instances would not be constructive or helpful criticism.

If a plan of operating through the counties were adopted, it would have the following advantages:

(1) The county organizations previously employed in each county to build roads could be utilized to maintain the state trunk system; that is, trained men familiar with conditions in the county

would be put in charge of the maintenance work in each county.

(2) The equipment owned by the counties would go a long way in providing the necessary tools and machinery for the maintenance work, removing the necessity of purchasing duplicate machinery.

(3) The counties, represented by their local officials, would be actually doing the maintenance work, and the general public would criticise them as freely as it would state officials doing such work. The Highway Commission's criticism of the counties' work probably would be much broader and more constructive than the counties' criticism of state work would be.

(4) The fact that the local officials were actually in charge of the maintenance work would inspire them to want a larger mileage maintained locally, and through their efforts sentiment would be developed for the proper maintenance of additional roads in every community.

The possible defects of this plan would be:

(1) The lack of co-operation between the county officials and the State Highway Department.

(2) The possibility of work costing more than in should, due to lack of proper supervision.

(3) The possibility that some of the work would be done in a more or less slip-shod manner.

After weighing both plans thoroughly, the Commission decided to operate through the counties as a unit, primarily because it believed that the sentiment which would be created for the improvement of roads other than those contained in the State Trunk Highway System would eventually more than offset the possible inefficiency and other unsatisfactory features of this plan.

Organizing a Patrol Maintenance System

In April, 1917, a law was enacted creating a State Trunk Highway System to be selected by the Highway Commission and a special committee of five legislators appointed by the Governor. The law provided that on May 1, 1918, the counties must take over the maintenance of the system selected.

For convenience in handling road matters, the Commission has established nine divisions, containing approximately eight counties each. A resident engineer, called Division Engineer, is in charge of each division, having the necessary assistants properly to plan and supervise the work in each division. An assistant, known as Division Maintenance Engineer, has charge of all maintenance, marking and signing. The latter visits each patrolman at least twice a month, reporting each visit by a card to the main office. In 1922, 10,940 visits were reported, giving us accurate information at all times as to the exact condition of each section.

Each county is governed by a county board, consisting of a representative from each township and village and also one from each ward of every city. The county board elects a committee of three to represent it in all matters connected with road work, and also elects a county highway commissioner who has direct charge of all road construction and maintenance work done by the county. Each county highway commissioner has an assistant known as Patrol Maintenance Superintendent who is in charge of maintenance. He visits each patrolman at least twice each week, insuring very close supervision.

The county road committee really acts as a board of directors and as a buffer between the county highway commissioner and the county board on the one hand and the State Highway Department and the county board on the other.

Prior to the selection of the system authorized by the legislature, our division engineers made a condition survey of all competing roads showing the actual conditions existing on every mile. After the selection of the system another survey was made, at which time the distance was measured accurately and stakes set each mile locating future mile posts. The information on each mile shows by tenths of a mile the soil, drainage, type of surface and condition. This information was very helpful later on in planning the patrol system in each county.

The law under which we operate did not provide especially for a system of patrol maintenance. It did, however provide that "each county must adequately maintain the portion of the system lying within the county, according to the specifications, directions and to the satisfaction of the Highway Commission."

The Commission determined, however, that a thorough patrol system must be installed at the very beginning which would cover every mile on the system, whether previously improved or not. The portion of the system lying in each county was divided into patrol sections by the county committee, acting jointly with the county highway commissioner and

our division engineer. The patrolman for each section was selected in the same manner. The county committee advertises in the local press that on a certain day those seeking the jobs of patrolmen for the coming season must report at the county courthouse. The applicants "if new" are interviewed by the county committee and our division engineer and the most promising candidates are given the positions. Applicants having served as patrolmen one or more seasons are given preference over new men and they usually receive more salary.

Each patrolman enters into a written contract with the county and gives a bond in the amount of $500 for the faithful performance of the work and proper care of the tools and machinery entrusted to him. The contract is also subject to the approval of our division engineer.

"On "team patrol sections" the patrolman must furnish a team and wagon satisfactory to the county, the county furnishing a light blade grader, road planer, plow, slip scraper and miscellaneous small tools. On "motor truck or tractor patrol sections" the county furnishes all the equipment.

The salaries paid on team patrol sections range from $140 to $165 per month for the 1922 season; those on motor truck and tractor patrols average about $110 per month. The season extends from about April 1 to December 1, and from December 1 to April 1 the patrolman agrees to work when requested at a fixed price per hour.

The "team patrol sections" average about six and two-thirds miles each, and as a rule are confined to earth road sections and those gravel sections that carry light traffic. We have few tractor patrol sections. They average about twelve miles in length and are generally confined to earth roads but are sometimes preferable on heavy traffic gravel roads where heavy maintenance equipment is necessary. Motor truck patrol sections average about 18 miles, and are economical only on heavy traffic roads where heavy maintenance equipment is necessary and where new material must be hauled regularly, on surface treated stone or gravel, and for work on concrete surfacings. We find that on earth or gravel sections where traffic does not exceed an average of 200 vehicles per day the "team patrol" is cheaper and more satisfactory than any other.

Maintenance Costs (State Trunk Highways)

The 1917 legislature provided for a 5,000 mile State Trunk Highway System, which the legislature of 1919 increased to 7,500 miles.

Table I shows the actual miles maintained by patrol methods each year, the number of patrol sections, the salary paid patrolmen, the patrol maintenance cost of each type per mile, and the amount expended per mile out of maintenance funds for "betterments." "Betterments" consist of widening the road and providing drainage with heavy blade grader work, light resurfacing, new culverts, and the cost of marking and signing the system.

County Trunk Highways

During the first month of patrol maintenance in 1918, the actual driving conditions in Wisconsin were improved far beyond the expectations of the most optimistic friends of patrol maintenance. Again when the entire system was adequately marked during the week of June 22, 1918, making it possible for the dumbest person from Illinois, Iowa, Minnesota or any other state to travel the length of Wisconsin without asking directions, our hopes were fully realized and the public expressed approval of the system in no uncertain terms.

Several county boards met during the

TABLE I—DATA ON PATROL MAINTENANCE IN WISCONSIN

Year	1918	1919	1920	1921	*1922
Actual Miles Maintained	4,998.9	4,998.9	7,234.0	7,260.4	7,458.59
No. Patrol Sections	561	561	791	911	940
Monthly Salary Team Patrol...	$ 130.00	$ 145.00	$ 165.00	$ 155.00	$ 150.00
Monthly Salary Motor Patrol..	90.00	110.00	125.00	115.00	100.00
†Earth	135.21	154.01	187.24	196.21	186.40
†Gravel	120.80	133.63	184.68	193.85	183.25
†Stone and Gravel Surface Treated	574.21	626.33	706.11	682.23	671.84
†**Concrete	162.21	210.42	220.18	322.21	311.85
Cost Patrol Maintenance	573.042.16	767.302.12	1,220,535.00	1,326.927.24	1,355.900.00
Cost of Betterments.....	396,449.65	488,529.68	756,474.38	1,028,976.04	952,850.00
Cost of Marking & Signing...	7,888.22	17,776.16	28,820.61	20,462.14	41,250.00
Total Expenditures	$977,430.93	$1.273.607.86	$2.005,829.89	$2,381,413.85	$2,350,000.00

The above total expenditures average $278.00 per mile per year.

*Final costs will vary somewhat from figures shown, as the season is not complete at this date (Dec. 15, 1922).

**Annual costs include all shoulder maintenance, which runs high on all surfacing less than 18 feet.

TABLE II—COUNTY PATROL MAINTENANCE ON SECONDARY ROADS

Year	1918	1919	1920	1921	1922
Miles Maintained	2,021	5,590	7,743	8,980	9,885
Number of Patrolmen	232	705	970	1,123	1,236
Average Monthly Salary of Patrolmen	$ 125.00	$ 140.00	$ 160.00	$ 150.00	$ 145.00
Cost of Maintenance	475,000.00	1,226,267.00	1,435,527.00	1,867,615.00	2,279,804.00
Cost of Marking and Signing		3,600.00	9,300.00	8,100.00	11,000.00
Total Expenditures	$475,000.00	$1,229,867.00	$1,444,827.00	$1,875,715.00	$2,290,804.00

The above total expenditures average $214.00 per mile per year.

month of June, 1918, and provided for adopting patrol maintenance on important secondary roads. The growth of this sentiment is shown by table II, showing the miles of county trunk highways taken over for maintenance each year by the several county boards, number of patrolmen employed, salary, cost of marking and signing, and total expenditures.

Table II, bears out our original ideas and proves to us, at least, that the plan of operating through the counties has resulted in local demands for more roads to be maintained each year by patrol methods and consequently a much greater mileage of patrolled roads. In addition to the 7,500 mile State Trunk System, we now have a 9,880 mile County Trunk System, making a total of 17,380 miles of well maintained roads. This gives more than 80 per cent of our population direct service, and brings patrolled roads within two miles of the remaining 20 per cent.

Results Obtained.

The "Wisconsin Idea" from the very beginning has been to "serve traffic." The patrol maintenance plan adopted in 1918, improved upon from year to year, and extended to include additional county highways each year, has certainly "served traffic" better, and satisfied the public to a greater degree than the expenditure of the same amount of money each year in constructing a few miles of high type surfacing would have done.

After five years of patrol maintenance we find that the following conditions prevail:

1. Every town, city or village in the state is on a well maintained and marked highway.

2. Traffic is distributed over a large mileage, reducing congestion on many highways.

3. The average speed of traffic has been increased at least ten miles per hour, resulting in time saving beyond computation. W. W. Rowland ("Brownie"), of the Milwaukee Journal, drove the entire length of our longest State Trunk Highway (No. 10) from Superior to Beloit, a distance of 492 miles, between sunrise and sunset, May 25, 1922. Deducting time for stops, he averaged slightly over 40 miles per hour the entire distance. Most of the surface is light gravel, there being but 28 miles of concrete on Trunk Highway 10.

4. Night driving is safe and practical and our traffic census shows a marked increase each year in night traffic. Prior to five years ago, no sane person would think of driving from Milwaukee to our northern lake district during the night (300 miles), while now the practice is becoming very common and popular.

5. Prosperity immediately becomes noticeable. The farmers along such routes soon vie with each other in promoting neatness in their road fences, farm buildings and entrances. Farm names appear over the gateway and the mail boxes are given a fresh coat of paint. Letterheads even show the location of the farm by Truck Highway route and mile number. Products of the farm are sold direct to the city dweller at a price satisfactory to both. In the villages and cities along the route new "Inns" or "Tea Rooms," rest rooms and garages spring up to serve traffic.

6. Last, but not least, is the tourist, and our definition of a "tourist" is any person using our highways for pleasure, whether residents of Wisconsin or not. They tell us that we have the best maintained and marked highway system in the world. We realize that nature has provided Wisconsin with scenic features in abundance; nevertheless, the tourist today would not be with us if our highways did not make traveling by motor car a pleasure. It is extremely difficult to estimate the total amount spent in Wisconsin by tourists. From the most accurate data available we are confident that it now exceds $100,000,000 annually. The little village of Kilbourn, located at the lower entrance to the "Dells of the Wisconsin," containing a population of but 1,200 people, furnished us accurate records kept by the banks, hotels and business houses for the 1922 season, showing that over one million dollars was left in that vicinity alone by tourists; also that a count taken by the business men's association one night registered more people camped in the Village Camping Grounds

than were living in Kilbourn. Practically every town on a patrolled highway now provides a free camping ground for tourists.

We are satisfied that during the five years of patrol maintenance, 1918-1922, the tourists have left not less than $300,000,000 in Wisconsin. Figuring a net profit of but 20 per cent, which is very conservative, the profits from this source would be $60,000,000, or about seven times the total expended for patrol maintenance and marking and signing the State Trunk System since April 1, 1918.

The Future of Patrol Maintenance.

We are satisfied with the progress made and the results obtained through our patrol maintenance system during the past five years, *but not contented.* Our patrol maintenance has improved each year and *will continue to improve.* The surface has only been scratched insofar as marking and signing is concerned. We will abandon the telephone marker as rapidly as possible, replacing them with standard markers placed along the shoulders of the road. Special signs were erected in 1922 at the entrance to each city or village, giving the name and population. In 1923 we will place signs at all lakes and streams, giving their names. Following this, signs will direct the traveler to all scenic and historic places, both on and off the system, giving direction and distances to them. Certain shaped signs will be erected along the shoulder of the road to denote certain dangerous conditions. One shape will indicate "Stop;" another "Slow;" another "Caution;" and another that the highway which you are traveling turns either right or left. There is really no limit to the service that can be rendered traffic along the line. We naturally feel a certain amount of pride in our marking and signing, and especially in the marking of all detours around construction work and the Highway Service Map published weekly showing roads open for travel and their condition, also the detours and their condition.

We expect local sentiment to continue to develop from year to year. We hope to increase our State Trunk Highway System to 10,000 miles in 1923, which will permit the counties to take over 2,500 miles or more of the most important town roads remaining. We expect that within five years the counties will be maintaining 20,000 miles in addition to the State Trunk System, making in all about 40 per cent of our total road mileage.

The local authorities will never adequately maintain the roads they use daily, and if the town roads are ever to be improved, they must be taken over by a larger unit of government. We are optimistic enough to feel that in the not too distant future the counties will take over all of the important local town roads and apply patrol maintenance, believing this to be the only practical solution of the town road problem.

After five years of patrol maintenance, we are confident that the people of our state are completely sold on the plan and are willing to pay for the pleasure and convenience it has given them.

The time may come when we will favor direct state maintenance. However, the thorough co-operation of the county officials in actual charge of maintenance and the sentiment developed by them locally for additional patrolled roads and road improvement in general, confirms our original opinion that the co-operative plan of maintenance would result in the greatest good to the greatest number in Wisconsin.

The foregoing paper by Mr. Donaghey was presented at the recent annual meeting of the American Road Builders Association.

THE PROVINCE OF THE HIGHWAYS IN THE NATIONAL TRANSPORTATION PLAN

By C. C. Williams, Head of Department of Civil Engineering, University of Illinois, 201 Engineering Hall, Urbana, Ill.

A few years ago, it was my pleasure to go out through St. Paul's Gate at Rome and traverse with frequent stops the Appian Way, and to have the opportunity to observe that admirable highway running off to the southeast from the city, which has been in continuous use for about 2,000 years, although resurfaced of course many times in that period. Jogging along behind a lazy team of skinny horses, my thought was directed first to the remarkably good roads built by the Romans, and second to the plethora of oratory that I have been compelled to listen to at various times and occasions on the theme of Roman roads as an argument for building similar roads in our own day.

This reasoning from ancient Roman civilization to modern American social and economic conditions is much more likely to lead to pedantry than it is to sound policy, hence I shall not do more than to

take the suggestion of a theme from the comparison.

The fact that Rome was a militaristic nation and had highways only for inland transportation compelled the construction of good roads, as the only means of moving armies and supplies. As a matter of fact, her boasted highways were probably about equal to the second class highways of Illinois at the present time, although more substantially constructed. Whether a peace loving America, restored to "splendid isolation," with an extensive network of railroads whose capacity incomparably exceeds the Roman highways and with a possible system of magnificent inland waterways available, should build large capacity highways will certainly have to be decided on the basis of present needs rather than the argument "because the Romans did thus and so."

However, one important fact stands out. The Roman empire was an efficient governmental machine, and so far as the Italian peninsula was concerned, was fairly well knit together. The well designed highways doubtless contributed largely to this result because they constituted a relatively effective transportation system. Highways alone served the purpose of the Romans, for the transportation afforded was in keeping with the entire life and customs of the time, but our civilization is built around a high velocity transportation, and low velocity transportation facilities will not serve the modern purpose adequately.

The agencies entering into our national transportation, so far as carrying of commodities is concerned, are: (a) externally, the merchant marine and (b) internally, the inland waterways, the railways (steam and electric) and the highways. Whatever development may occur in aerial transportation, it will probably have but little bearing on highway and other forms of transportation. The proper development of these agencies of transportation requires coordination into the most efficient relationship rather than an independent program for each.

Inland Waterways

The extent to which inland waterways may be economically developed in America is a much mooted question, and it is not the province of this paper to enter into the discussion. I may say, however, that it is only a question of time, in my opinion, when Chicago and other cities on the Great Lakes will be virtually ocean ports through the completion of the St. Lawrence Water Way and also the cities on the Lower Mississippi will have the advantage of direct oceanic shipping by having lighters ply directly between their wharves and ocean going vessels, much as is done at Paris on the Seine and at ports on the Rhine. The Middle West cannot continue to be strangled by being compelled to force its foreign trade through a bottle neck at New York. I believe, therefore, that a limited system of inland waterways will be an essential part of our ultimate transportation facilities.

Moreover, I believe that in the due course of time, sectional prejudice and jealousies, which so frequently obstruct the view of national policies, will give way to a recognition of the necessity of national marine shipping, and that we shall have an oceanic merchant marine, even though subsidizing may be required for its successful operation. The prosperity of the nation as a whole is dependent to so great an extent upon the adequacy and reliability of our foreign shipping and the prosperity of one section is so inextricably bound up with that of the nation that it is short sightedness for one section of the country to attempt to divorce its economic policies from those of the nation and have no interest in a measure of such importance to the nation as a merchant marine.

Let it be assumed then that these agencies are to constitute our national transportation machinery and that they are to be co-ordinated according to some plan, so that we may proceed under the title of this article. Thought must be given to the relation which these agencies should bear one to the other, and it is the purpose of this discussion briefly to direct attention to that question.

Do the external transportation facilities have a bearing on internal transportation strategy? This factor should certainly be taken into account, for our internal lines of traffic as well as port facilities must be planned with a view to the traffic routes of the world. Does not the fact, for example, that the opening of the Panama Canal has made New Orleans the second port in the U. S. have a significance? It does, for if our traffic is to go in that direction, our internal traffic lines should be arranged to provide for shipping accordingly. Obviously our internal transportation lines must be arranged in a measure with a view to the traffic routes of the world's commerce and cannot be properly fixed with reference to internal needs only. Therefore it may

be taken for granted that our national transportation plan will need to be a comprehensive one and will include marine shipping facilities.

Present Extent of Transportation Facilities

The internal transportation agencies consist of the following:

15,000 miles of inland waterways, in a more or less workable condition, consisting chiefly of rivers. 260,000 miles of steam railways and 40,000 miles of electric interurban railways, 2,500,000 miles of highways, 12 per cent of which or 300,000 miles are improved highways.

These agencies, should be co-ordinated into a plan with two objects in mind, namely: (1) efficiency in economical transportation and (2) factor of safety against failure of the transportation machine. To achieve the former, each agency must normally perform the service for which it is best adapted; to achieve the latter, the highways should be so linked up with both the railways and the waterways that either of the latter may be cut out when incapacitated by strikes, floods, a public enemy, or other cause and still permit the vital activities of the country to proceed, although inefficiently.

Specifically in this scheme, what shall be the function of highway transport?

Obviously all these agencies constitute the commercial circulatory system of the country, the railways and waterways being the arteries and veins and the highways serving primarily as the capillaries. The highways should begin where the trunk line agencies leave off. They should cover the country as an area rather than operating between certain urban centers.

At the same time, in order to provide the necessary transportation when the railways may be out of commission, there will obviously be needed certain trunk line highways between large industrial and commercial centers. These will necessarily be paved with a surface capable of sustaining heavy truck loads. A hard surface double track highway, it may be stated in this connection, increases the transportation capacity (speed x time available x load carried) about ten times as compared with an unimproved earth road. This increase in transporting capacity is comparable with the ratio of increase in capacity if a single track railroad were changed to a six track line.

Traffic Increases

All of these agencies of transportation are needed if we are to have reliable and adequate national transportation. Some years ago, I had occasion to make some studies with reference to the variation of traffic with the increase in population. The data collected show that freight traffic increases with the 3rd to the 7th power and passenger traffic with the cube of the population. In 1910 the population of the United States was about 91 million and at present it is about 110 million. The traffic requirement, therefore, has more than doubled in the past ten years, assuming the traffic to increase with the 4th or 5th power of the population. That this increase in traffic is not being carried by the railroads is evident from a casual study of the increase in their capacity. Since 1910, the railroad mileage has increased 9 per cent, the freight cars 20 per cent, and their actual traffic in ton miles carried, 40 per cent. Obviously a large amount of transportation is being taken care of by agencies other than the railroads, the chief of which is the highways. During the war the railways were found to be inadequate to care for the nation's transportation and almost constantly now they are found to be deficient in certain respects. The railways at present have a total transportation capacity much below the nation's requirements, and if the highway transport were not available, the public would be suffering from clogged commerce even more seriously than is the case now. Therefore we may conclude that we shall need all available agencies of transportation. Indeed, unless the capacity of our national transportation system is increased rapidly in the near future the nation's commerce will be seriously hampered because of the lack of transportation capacity.

With our present highway transport facilities, while no figures are available as to the actual accomplishment of trucks, it is probably safe to say that the freight movement by trucks competitive with railways is small as compared with the 500 billion freight ton miles annually carried by the railways. The present contribution consists of terminal, local urban and rural carriage, and it is in this respect that the highways are contributing so largely to the transportation required by the country.

The Function of Highway Transport

In fact, this, as stated before, is the natural sphere and function of highway transport. While an explicit statement as to the economic length of haul for motor trucks as compared with railways

is impracticable, yet even a casual study of operating costs readily reveals that trucks cannot compete with the railways normally for very long hauls, even for L. C. L. freight, and they are out of the running for most C. L. freight. Roughly 25 cents represents operating costs per ton mile by truck and less than 1 cent covers operating costs of haulage by rail, and it does not require a very long haul to cause the greater haulage cost to more than offset the costs of handling at terminals. The exact distance at which trucks can compete with the railways will be determined by balancing the following items for railroad haulage, namely:

Cost of crating and packing; cartage to freight house from shipper's warehouse; cost of unloading; cost of loading to trucks at destination; cost of cartage from freight house to the consigner's warehouse; losses due to damage and theft, and cost of delay in delivery, against: The greater haulage cost by trucks and the cost of additional insurance required in truck transportation.

Just what the answer is to this equation in any particular instance depends obviously upon labor costs, the distance of local haul to and from freight houses, and the character of the cargo. The value of quick and direct delivery makes it possible to haul fruit and other commodities which either deteriorate rapidly or are subject to a heavy market demand, distances far exceeding the economic haul when this factor is not important. In fact this factor may increase the economic haul from 7 or 10 miles under normal conditions when the value of expeditious delivery is neglected to 150 or 250 miles when the factor is maximum.

Illogical Basis of Freight Rates

In order that there may be a proper adjustment of function between railway and highway transport it is necessary that railway rates be placed on a more logical basis than they are at present. Without reviewing the history of railroad rates at length it may be stated that they are entirely arbitrary and in most cases bear little relation to the cost of rendering the service. The rate structure with all its eccentricities and absurdities was crystallized in 1889 when an interstate commerce law was passed requiring no change in rates be made without approval. Since that time only horizontal increases or decreases, and minor adjustments have occurred. The entire rate structure shrieks loud for fundamental revision and placing on a rational basis of cost of service.

A very large proportion of the cost of railroad transportation consists of station or terminal expenses. Loading and unloading, trucking, weighing, etc., make up a startlingly large cost which must be provided for in freight rates. Moreover, the real estate occupied by downtown freight houses in large cities is so valuable that the fixed charges run unduly high. Mr. E. H. Lee, Chief Engineer of the Outer Belt Railway of Chicago states that the fixed charges are more per ton on freight passing through Chicago freight houses than are the costs of handling the freight through these houses. It has been stated by good authority that the total terminal cost per ton at New York is so great that the rate to all points within 100 miles should be constant, the actual haulage cost being negligible in comparison; and that this terminal charge at New York is as great as the haulage charge to Buffalo. Yet our freight rate structure practically neglects this fact of station and terminal costs, the L. C. L. rate being irrational and inadequate.

Rational Rates

A freight rate to be rational should consist of the following elements: (1) a station or terminal charge plus (2) a haulage charge plus (3) insurance charge plus (4) a commercial differential.

The terminal charge should be determined by the actual cost of handling for the different classes of freight. The handling element of this charge would depend upon the space ocupied. The terminal charge would also depend upon the facilities involved, whether a siding, a crane, an elevator or a freight house with hand trucking. The difference in rate between L. C. L. and C. L. freight is supposed to provide for this factor, but it does not do so adequately.

The haulage charge would depend upon the weight and space occupied by the commodity which would affect the proportion of pay load in the combined weight of car and cargo. Fifty tons of furniture or automobiles that would require four cars obviously should bear a higher haulage rate than 50 tons of coal all in one car. The haulage charge would vary directly with the distance the cargo is hauled.

Insurance against damage and theft is a definite and legitimate charge because the risk is a real and, to a certain extent, an unavoidable one. This factor also enters into all forms of transportation, and should be duly considered in any comparison of agencies of transportation.

The commercial differential would nec-

essarily constitute a part of the rate in recognition of the ability of certain classes of commodities to bear a heavier freight rate than others. Practically this element might properly include the third or insurance item. It would be a percentage of the value of the commodity and would correspond to the profit that any business received for handling a commodity.

Such a three-part scheme of rates at first thought would seem further to complicate the rate structure even beyond the labyrinthian complexities of the present. On the contrary it could greatly simplify the rate structure by unifying and simplifying freight classifications and eliminating special commodity rates.

The gain to be derived from a rational freight rate structure would be the natural selection of facilities and the operation of the various agencies of transportation in the spheres to which they are best adapted.

Notwithstanding the higher rates for short haul L. C. L. freight it is the business on which the railways at present make the least profit owing to the expensive station handling. If rates were made in proportion to actual cost of rendering the service, this business would naturally fall to trucks which are in a position to eliminate the waste of labor at the station or terminals.

The logical function of highway freight transport, therefore, consists of local distribution from and to the railroad and short hauls of L. C. L. freight between towns. In addition to this a certain amount of truck line transportation should be made possible over the highways to provide for the emergencies when the railways may be thrown out of commission by strikes, by floods, or any other contingency.

The Supplementary Function of Highways

It is economically impossible to construct all highways to carry even moderately heavy loads, and economically impossible to construct even trunk lines to carry the loads which some would desire to place upon them. In other words, the highways cannot economically be designed to carry loads which might make possible their competition with the railways for heavy and long distance transportation. Moreover, with the highways designed as they must be for light moderate damage to the highways than a thousand light to moderate loads. Obviously it is not fair to allow 5 per cent of the traffic to do 95 per cent of the damage to the roads, for the cost of construction and maintenance is distributed in no such ratio. If license fees are properly adjusted, unduly heavy loads will be kept off pavements not designed for them, and with such fees supplemented with rigorously administered fines for violating the legal limitations the entire control of the situation may be secured.

This aspect of the question might be enlarged upon further but enough perhaps has been said to indicate the conclusion—a conclusion indeed which is not new but which has been pointed out by several others—namely that the function of highways transport is to supplement the railways and the waterways rather than to enter into competition with them. This is an economic conception and like most economic principles, physical or engineering instrumentalities are necessary to make them effective.

Highways may supplement railways first by securing more adequate local transportation in the areas which have heretofore been served by the railways, namely, the region extending 5 to 10 miles on either side of the railway, and second, they may bring transportation service to the more remote areas which have been very inadequately served.

The Container Car

The container car, which has recently come into use and which has been described at various times in the engineering periodicals, bids fair to furnish the liaison instrumentality for making this supplementary co-operation real to a great extent. In this scheme the bodies of the trucks are lifted by crane directly from the truck to the car, about eight or nine truck bodies constituting the body of the car. Much of the expense in handling is thus eliminated. The chief difficulty is the lack of corresponding facilities at small way stations. However, this or some similar device will probably be used extensively in the future to effect this co-operation which most students of the question agree is desirable. Mr. W. H. Lyford at a recent highway conference at Washington, made the statement that "In Chicago, the interest charge alone on real estate at 12th street on which a freight station is located is $2.30 per ton of freight handled through the station. If the station were located at 33rd Street, such interest charge would be about 80 cts per ton. The amount of interest saved by moving the station to 33rd street would pay the cost of well organized cartage between 33rd street and the premises

of the trader." A few years ago, while working on the design of a freight house for the C. M. & St. P. Ry., I had opportunity to make a study of the actual conditions of congestion at the downtown freight houses in Chicago and I may safely say that the delay in loading and unloading at the platforms costs the Chicago shippers many thousand dollars daily. Here, then, is a proper field of co-operation in large cities.

The collection and delivery of freight by the railroads with their own drays or trucks, as is done in England, is probably not feasible under our present scheme of organization, because it would be wasteful of effort for every railway to maintain its own truck or cartage organization even in a large city. The solution to this situation may lie in a further extension of terminal railways, which will handle all transportation, both on rail and on street, within the city, and turn the cargoes over to the various lines to transport to destination, to be turned over there in turn to a corresponding terminal transportation concern for delivery. In fact the terminal railway is so demonstrating its entire justification in large cities from various considerations that it promises to be adopted in all large cities. If terminal railways miss the opportunity of performing this store door delivery service, the alternative seems to be terminal trucking organizations, which in my judgment would be a less satisfactory scheme.

The second aspect of the supplemental co-operation between railways and highways is an important one and one whose influence will extend in the future; that is, the more completely bringing transportation service to districts remote from railways.

Until the railways were built the United States consisted of a line of commercial states along the Atlantic seaboard, a wilderness nominally organized into states west of the Alleghenies, whose settlements were limited to towns along the rivers. The advent of the railways wrought a mighty change. Inland cities sprang up and the railroads deliberately developed industrial centers with a view to their future traffic business. This scheme of economic development was satisfactory until the large industrial and commercial centers grew so large and required transportation service beyond the capacity of the railroads. The urban centers of commerce and industry that owe their location and size largely to railroad strategy, are now threatened with strangulation due to the lack of transportation capacity on the part of the railways. Will the advent of highway transport effect a new distribution of commerce and industry in turn a further scattering, corresponding to that change which the railways wrought over the distribution based solely on waterway transport? Only the future can show just what the answer will be, but it seems safe to predict that extensive fundamental changes will result in this connection. Our present commercial and industrial distribution and entire economic fabric are a product or function of the railways; the future will be a function of a more comprehensive transportation system, which by virtue of the highways will be more elastic and more nearly cover the country as an area than does a network of railway lines.

Multiple Axle Trucks

Recent developments in multiple axle trucks give promise of removing the heavy concentrations from the pavement and thus permit heavy loads to be safely carried over the pavement. The 6-wheel truck is becoming fairly common in this country and a 10-wheel truck was recently tried out in London. In this respect, the development by extending the length along the track is entirely analogous to the development of the steam locomotive from one pair of drivers to 8 or 10 pairs.

Passenger transport in cities by motor vehicles perhaps should be mentioned in this connection. Here again proper coordination and co-operation instead of competition will yield the best service as well as the largest net returns to all concerned. Many cities where no electric railways have been established are using motor busses as local transportation with satisfaction. Several large cities, notably Providence, Newark, N. J., Baltimore, Washington, Rockford, Ill., and Tulsa, Oklahoma, have established a co-operation between bus lines and electric railways for covering outlying districts. The fact that practically all electric street railways in the country are in financial difficulties, varying from non-payment of dividends to receivership, leads one to question whether the surface street car line for local transportation of short haul in large cities is not an obsolescent instrumentality. Observation in London and Paris as well as in New York seems to indicate the street railway's proper function to be cross-town transportation. If street car lines are to be limited practically to cross-town transportation and local transportation in heavy traffic areas,

auto-bus transport may be counted on to provide for local traffic under ordinary conditions and to afford transportation for outlying districts. Superior service in transportation also can be furnished for high class residence districts where street car lines are not satisfactory for one reason or another.

Summarizing, I would say that the agencies of transportation should be coordinated into a unified and comprehensive plan, as a basis of which two principles seem apparent: (1) the highways should supplement rather than compete with the railways and waterways and by logical adjustment of transportation rates and of taxes, each agency should be brought to operate in the sphere to which it is best adapted and (2) the highways should be so linked up with industrial and commercial centers and marine ports that either the railways or the waterways might be out of commission by strikes or other cause and yet the vital activities of the country proceed, even though inefficiently. How this supervision of transportation planning is to be accomplished is another question. Transportation as a factor in national life is on a parity with Commerce, Agriculture or Labor and these phases of our economic life are represented by departments in the President's Cabinet. Other countries have placed ministries of transport even ahead of some of these. Possibly a feasible solution is to place the Bureau of Public Roads, the Interstate Commerce Commission, the U. S. National Waterways Commission, the U. S. Shipping Board and other related bodies into one Department headed by a secretary of transportation in the Cabinet. Whatever device may be the best for effecting the desired arrangement, it is eminently desirable that there be a plan which will be comprehensive and unified, and adequate to provide for the transportation requirements of the nation with the maximum degree of reliability, efficiency and economy.

The foregoing paper by Prof. Williams was read at the Short Course in Highway Engineering, University of Illinois, Feb. 19, 1923.

MAINTAINING EARTH ROADS IN IOWA WITH BLADE GRADER AND DRAG

By W. H. Root, Maintenance Engineer, Iowa State Highway Commission, Ames, Iowa.

On Jan. 1, 1923, the primary roads of Iowa were classified as follows:

Paving	334.4 miles
Gravel	1558.0 miles
Graded and drained	1761.1 miles
Not built	2961.8 miles
Total	6615.3 miles

In other words, out of 6,615 miles of primary road, 4,723 miles or 71 per cent of the whole system are unsurfaced. The Iowa Highway Commission has chosen to look upon its primary road system as the backbone of a state-wide transportation system. They believe that the public is entitled to a usable system of roads whether such roads have been constructed or not. As a result of this policy the maintenance forces of the state are required to maintain the whole 6,615 miles of road, 45 per cent of which has not even been built to an established grade line, and of which 71 per cent is ordinary earth road. These figures show, I believe, that the Iowa maintenance problem is an earth road problem and they explain why we have concentrated on earth road maintenance.

The Heavy Blade Grader

I think that I can state without the least reservation that the most useful and indispensable tool for the care of earth roads is the heavy blade grader. By this I mean a grader with a blade length of from 12 to 16 ft., built heavy enough to do work that will require 30 to 50 drawbar horsepower. A blade grader of this sort is adapted to various kinds of work. The three main classes of blade work are:

1. Heavy blade work on roads which have never been built, that is, widening out and building to standard cross-section trails which have never really merited the name "road."

2. Finishing work on new construction.

3. Surface smoothing operations supplementary to regular patrol work.

I will try to show how this work is carried on in Iowa. It was in 1913, I believe, that the first 12 ft. blade machine was shipped into the state of Iowa. Now there are at least 400 of these machines in the state. In our early blade grader work we erred in not doing a thorough enough job. We paid little attention to getting the fences back to the line and clearing the right of ways. We merely shaped up the road as we found it. From 5 to 10 round trips were made and the total cost per mile was only $50 to $75. Each year, however, we have attempted to do more work and get a better road. We now require the fences and

telephone poles to be moved back to the highway line before we start work. All trees, stumps and boulders are then cleared from the right of way. This work alone in some parts of the state, runs as high as $200 or $300 per mile. All heavy weed growths are also cut and raked up and burned. After the right of way has thus been cleared we are ready to start the blade work proper. The ditch line is staked out (18 ft. each side of the center line) with lath. Enough lath are used so that two laths are always visible to the grader operator.

Each mile of road is a problem in itself. An ingenious grader operator will save lots of time and money by cutting down the number of round trips necessary. High side banks, narrow fills off center, and wet ditches are only a few of the things that make a first-class blade grader job difficult and expensive. We much prefer a blade grader with a back sloper attachement, that is, an attachment which may be bolted on the end of the blade so that the ditch bottom and back slope may be cut at the same time as the inside slope. A properly designed back sloper will cut the standard ditch and back slope when the main blade is cutting the standard inside slope. The back sloper should be adjustable so that the back slope can be flattened from 1½ to 1, to 2 or 2½ to 1 where extra dirt is needed.

On an average road we now make from 10 to 15 round trips with a single grader. Some counties still pull two 12 ft. graders with one tractor but I do not believe that this is economical. Where this practice prevails one grader of necessity must lie idle much of the time and the turning is more difficult. The average cost of our blade work including clearing, is about $150 per mile. However, we often have miles which run as high as $500 or $600 per mile. It is surprising the extensive work which is accomplished by some counties with the 12 ft. blade. We have built side hill roads in hilly counties where the material was mostly loose rock, and have had excellent results. Work of this sort when finished looks much more like permanent grading than it does like blade grader work.

No two miles of road require the same treatment, and the cost of blading, therefore, varies greatly. The following figures, however, roughly represent the cost of the average mile:

One engineer, 25 hours, at 75c	$ 18.75
One grader operator, 25 hours, at 60c.	15.00
125 gals. of gas, at 22c	27.50
Oil and grease	3.00
Depreciation on a $6,000 investment, figuring a three-year life of 100 working days per year, 2½ days at $20 per day	50.00
Estimated repair, 2½ days, at $5	12.50
Interest on investment (5% on $3,000), 2½ days, at $1.50	3.75
Clearing right-of-way and incidentals.	19.50
Total	$150.00

The second class of a blade grader work as outlined above, is the finishing of permanent grading. By permanent grading, I mean building a road to an established grade line which is presumably a permanent one. In grading operations in Iowa most of the dirt is moved with elevating graders and dump wagons. We insist on a Mormon scraper being kept constantly at work on the dump but the best job that can be done in this way is necessarily rough. Therefore, we require every grading contractor to have a 12 ft. blade grader in his equipment. This grader is pulled by a large engine and the road finished smooth close behind the rough grading. Often the same tractor that pulls the elevator, is used evenings and at odd times to smooth up the work.

We also find that all new grading settles unequally after a few rains. The shoulders usually become low and ragged, the ditches start to fill, and the back slopes sluff. It then becomes necessary to again blade the job. This last blading is done by the county as a maintenance measure. The back sloper is used. It fits into the ditch and back slope and builds the shoulder up in a uniform manner. The result is a workmanlike job, without perceptible waves and the cost is only $50 or $75 per mile.

The slogan of the National Paint Manufacturing Association "Save The Surface And You Save All" might be studied to advantage by State Maintenance Departments. The public judges a road by its surface. A road is good or bad, as it is smooth and comfortable to ride over at 35 miles an hour, or as it is rough and inconvenient to travel at that speed. The user of the road cares little for clean ditches and nicely lined shoulders, if the surface is rough. This suggests the third and most appreciated class of heavy blade work. We have the patrol system of maintenance in our state but on practically all earth roads on the primary system, we find supplementary maintenance with a heavy machine very necessary. For this work we again prefer the heavy 12 ft. blade grader. In a number of cases we have lengthened these blades to 16 or 18 ft in order to cover the road surface in one round trip. Often we are able to pick up old graders which have become

worn and loose jointed. These old machines can be bought for a song. We equip them with extension blades, put on heavy springs between the frame and the blade, to take up the play, and thus obtain an ideal maintenance machine.

The most difficult maintenance problem that we have is presented by a heavy soil road with heavy traffic, say a dense yellow clay road carrying 1,000 vehicles a day in all kinds of weather. It is obvious that before such a road has a chance to dry out so that it can be dragged, it has been hammered down until it is about as hard as a concrete pavement. However, the riding qualities are not at all similar to those of a concrete pavement. It is rough and rutted and anything but a pleasure to travel over. It is also absolutely beyond the control of any light equipped patrolman. Nothing but a heavy blade will ever put such a road back in satisfactory shape for travel.

Road Drags

This I believe, covers the field of the heavy blade grader. The road drag is also a widely used tool in our state but its work is not so readily classified. We have almost as many different kinds of drags and maintainers as we have operators. We have everything from 2 bladed drags weighing around 200 lbs. and easily pulled by 2 horses to big heavy maintainers weighing 1 ton or more and pulled by 20 or 25 horsepower tractors. I do not expect to enter into a discussion concerning the relative value of these different machines, suffice to say that they most all have their good points. In my opinion the man not the machine, is the important factor. I would rather have a live ingenious man with good road sense equipped with an old fashioned split log King drag than a "dumb-bell" with the fanciest maintainer manufactured.

We divide our earth into patrol sections of about 10 miles each. A patrolman is placed in complete charge of each section and he is held responsible for its care. He is usually equipped with a patrol grader, a drag, a slip scraper, a plow, and a set of small tools. He also has access to other equipment such as wheel scrapers, mowers, etc. He furnishes one team all of the time and in most cases has a second team which can be procured when needed. On the heavy soils we have to use four horses even on a small patrol grader. The patrolman's first duty is to keep the surface of the road smooth. To do this he must drag or see that the dragging is done, on his entire section as soon as possible after each rain. On light soils the dragging can be started after a few hours of sunshine following a rain and the equipment may be either a light patrol grader or a drag. A patrolman on this class of soil can care for his section with not to exceed one extra dragger. On heavy soils it takes much longer for the road to dry out sufficent to drag. Here the first dragging may be done by the patrolman but he will need 3 or 4 extra draggers. Often on this class of road the first dragging is done with heavy equipment.

In no case is one dragging enough. Lighter soils must be bladed with the patrol graders a second or third time until the surface is smooth. The first dragging on the heavy soils only partially breaks up the clods and incompletely fills the ruts. It must be immediately followed by a second or a third smoothing with heavy equipment. As stated before, we prefer a 12 or 16 ft. heavy blade for this final polish.

Summary of Policy

The Iowa earth road maintenance policy and activities might be briefly summarized as follows:

1. Realizing that we will have to depend upon earth roads on a large part of our primary system for a number of years to come, we believe that we are justified in an intensive maintenance program on these roads, in order to give the traveling public service while they wait for our construction program to eliminate the mud.

2. As a first step in this program we have graded with the heavy blade grader, practically every mile of primary road that has not been otherwise constructed.

3. For finishing grading which has been built with an elevating grader and dump wagon, the 12 ft. grader is a most useful tool.

4. The heavy blade is indispensable for surface smoothing especially on heavy soils.

5. Earth roads should be patroled and the patrol sections should not be over 10 miles in length.

6. All patrol and light drag work must be supplemented with heavy maintenance machines.

Our maintenance ideal is continuous, automatic care and definite, individual responsibility.

The foregoing paper by Mr. Root was presented at the recent annual meeting of the American Road Builders Association.

Construction News and Equipment

A DISCUSSION OF PRESENT PRACTICE IN CONSTRUCTING CEMENT CONCRETE PAVEMENTS

By E. G. Willemin, District Engineer, Michigan State Highway Department, Lansing, Mich.

In the consideration of present methods of constructing cement concrete pavements, it will be assumed that the foundation, subgrade or earthgrade and the drainage features of the road have received the painstaking care that is now considered absolutely necessary in good practice. For convenience the subject will be handled in the sequence of operation; that is, the methods employed in (1) the preparation of the flat subgrade or earthgrade for the slab (2) the movement and manipulation of material (3) the finishing of the concrete surface. The subject of construction details will also be considered as to their effect upon the builders' and users' viewpoint.

Preparation of Subgrade

In the preparation of the flat subgrade for the slab it is the practice in Michigan to channel out sufficient earth from the full width of the slab to such depth as to give the proper cross section and volume of earth to complete the shoulders at the edge of the slab. On fresh subgrade or upon loose soils a grader serves well to remove the excess earth outside the shoulder line for future use. On subgrades, well packed by traffic or in stiff soils, it becomes necessary to use heavier equipment in such tools as the plow, scarifier and grader. There has been and still is considerable discussion as to the merits of channeling for the slab. From the engineering standpoint in controlling volumes of earthwork it is necessary to use the surface of the flat subgrade or earthgrade as the plane which eliminates the item of excavation from further consideration. On the other hand, it means that the earth channeled from fills is handled twice. This fault is partly remedied by building our earthgrades 6 ins. wider on each side than the finished width, with the idea of using the wedge of earth of the inner ditch slope as a source of filling material for shoulders. In flat sandy country, channeling may be almost dispensed with, while in rolling country it becomes more difficult for the engineer to balance the deficiency that may exist in cuts and fills to avoid endwise haul. In practice it has been found advantageous to have the engineer actually channel out a strip several feet wide to the cross section, as shown on the plans to demonstrate that in that class of soil sufficient depth has been reached, with or without the wedge of earth on the shoulder, to fill out the shoulders adequately on the edge of the slab to its proper slope and section. The present tendency is to eliminate side ditches as much as possible, but still provide adequate drainage and yet leave no ghastly borrow pits on the back slopes. These restrictions imposed upon the engineer make close control of earth work necessary at all times.

Handling Material

The vital importance of the supply and transportation of material has already been touched upon. The supply should always be at least equal to, but never less than consumption requirements to insure continuous production with a well balanced plant. The facilities of unloading materials from a source involving railroad haul and for its proper storage is therefore given careful consideration. A layout that gives a minimum handling usually guarantees a decreased cost. Each time material is picked up to move, costs rise also, due not only to the cost of movement, but waste of material as well. Yard layouts are now designed to elevate raw material but once, if possible, and to take advantage of gravity movements thereafter. The clamshell, or adaptations of it, equipped with a ¾ to 1 yd. bucket is in geenral use and proves economical. A mobile machine of the caterpillar type gives general satisfaction, as it reduces switching charges, and needs no supporting track to run upon. From this point on the methods of handling materials will be determined by the location of the mixer in respect to the road, so storage and loading methods will be discussed under the different plant types.

Location of Mixer

Transferring our attention now from the unloading plant to the mixer, we find that in general two classifications may be made as to the location of the mixer, viz.: (1) the mixing operating on earthgrade fed by transportation units, (2) the mixer operating off the grade and delivering a wet batch to the transportation units. Under the first classification we may subdivide into three types, the wheelbarrow or stocking of subgrade system, the central proportioning plant or a type, not used to any considerable extent, which consists of a mixer over which storage bins are erected, the bins being filled by a hoisting arrangement and the whole cumbersome affair mounted on rails. Due to the fact that the transportation element must also be considered with each type of mixer layout, I will continue the enumeration of types of mixer layouts not operating on the subgrade, then return to a closer study of each type of layout in its relation to transportation, as well as its peculiar advantages over other types.

Under the classification in which the mixer does not operate on the grade we have two types. (1) A central mixing plant, with mixer fixed and set up adjacent to main source of material supply. (2) A modified central mixing plant where the mixer requires one or more set-ups usually adjacent to the road, its location determined by stock pile or source of supply. It will be noted that the essential difference in types as far as transportation is concerned is the hauling of a dry or a wet batch. There are other considerations previously mentioned, however, that largely determine the location of the mixer in respect to the road and the methods of transportation. I will repeat them as, soil of subgrade, gradients, width of subgrade, water supply, condition of adjacent roads, length of the project, supply of common and skilled labor, length of live and dead haul, availability of local material, time limit of the contract and capital investment.

Wheelbarrow Method

With the mixer operating on the subgrade, let us first consider the wheelbarrow method. This method is still in use, but usually in localities where unskilled labor is plentiful and cheap. Aggregates are usually stocked upon the subgrade. In such a case it is necessary to space the loads of each type of aggregate with care to save long distance wheeling. This requirement would mean a very trustworthy foreman in charge of unloading. Again with materials stocked on the subgrade any corrections that must be made to the subgrade after the aggregates are placed, are very costly. For this reason unusual care must be taken to correct all ruts and uneveness of the subgrade prior to stocking. There is considerable loss of material, as aggregates cannot be picked up clean and economically without combining parts of the subgrade with it. This waste material may run as high as 10 per cent. The human element enters into this method too largely; there is congestion, questionable morale and heavy labor turnover. There is no advantage in stocking subgrade in anticipation of scarcity of material that cannot now be offset by dry batch delivery from the stock pile. A late development is the use of belt conveyor as a substitute for the wheelbarrow. This contrivance eliminates the common labor element, but does not reduec waste of material. When aggregates are not stocked on the subgrade delivery of materials to the mixer may be made by industrial railroad, light or heavy truck. The reliability of mixer supply, however, is questionable in this method. Moreover, it has been demonstrated that the batch system handles the transfer to the mixer more economically. Unless material can be stocked at railroad siding, there is a possibility of the accumulation of demurrage charges.

Central Proportioning Plant

As the name infers, the central proportioning plant proportions the aggregates in a dry batch to correspond to the capacity of the mixer. The plant may be composed of fixed or movable loading bins that serve for storage of aggregate or a tunnel arrangement designed to accommodate an industrial train. Batches may be proportioned by hoppers on the discharge chute of the loading bin or tunnel or by volumetric measurements in compartments of a batch box or of partitional truck bodies. Batch boxes may be of the tilting, side discharge or drop bottom type. If cement is included in the batch, separate compartments for it are preferable. Covers are now provided for cement compartments as a safeguard against wind and rain. The ideal layout for loading is to elevate material but once, so that handling of materials to the transportation units is by gravity. In some large layouts using truck haul, separate loading bins for each aggregate are used. This arrangement requires two stops. In smaller

layouts, where truck haul is used, it is possible to have sand and gravel compartments for each loading bin, thus eliminating one extra stop of the truck per trip. There are likewise opportunities to design tunnels so as to economize on train loading time and dead storage of material.

Hauling Materials

In the consideration of the effectiveness of the central proportioning plant we are at once confronted with our transportation problem. In general the light or heavy truck or a combination of both, or the industrial train alone or in truck combinations, is employed. Tractor train haul has not proven adaptable as an economical method. A fleet of light trucks alone, equipped with pneumatic tires, capable of handling one 4-bag batch, have proven successful under certain hauling conditions. It is argued that the cost of delivery of material in this manner is no more than with a wheelbarrow layout, and that the cost of reshaping the subgrade that is necessary with certain soil conditions when heavy trucks are used is avoided. On a long haul by truck delivery it is also argued that a saving can be effected in handling of material by delivery in heavy trucks to a stock pile, provided the heavy trucks can dump directly into the hopper of a loading bin to be later discharged into hoppers for loading light delivery trucks. The cement may or may not be added to the batch at the central proportioning plant, depending upon the source of cement supply. It may prove feasible to stock the cement in a movable storage house on the road. The methods mentioned contemplate the material brought by truck or train to the mixer, with the mixer gradually progressing forward. A recent plant layout using dry batch heavy truck delivery was so arranged as temporarily to fix the location of the mixer every 1,500 ft. on the subgrade, with the mixer discharging concrete into light trucks for placement on the subgrade. It is needless to say that a turntable would be one necessary piece of equipment in such a layout.

Among road builders the problem of the transportation unit to be used for a given project creates considerable discussion. One builder's experience may have involved the light truck, another the use of heavy truck, while still another the industrial railroad. Contracts have been completed by the use of each type or of light and heavy truck combinations equally successful from the standpoint of the contractor. It is my opinion that the temperament of the contractor and his organization enters into the choice; in other words, a personal equation may be involved. Some builders are willing to take more grief from their equipment than others, as manifested by the maintenance they give the equipment.

Equipment Charges

Besides this consideration there are the more important ones of plant investment, fixed and operating charges. It has been found that certain economic principles apply as well to road equipment as to other types of machinery. Let us consider a few of these principles. It cannot be disputed that where interest charge on the investment plus depreciation is exceeded by the loss due to costly delays in the use of old equipment that new or better equipment should have been purchased. The economy of new or well maintained equipment is apparent where repairs or replacements are difficult to obtain. A piece of equipment is not justified in a well balanced plant unless it co-ordinates closely in output with other units of the plant in giving continuous production. This does not mean, for instance, that the capacity of the clam at the unloading plant per ten hours must be equal to the total aggregates handled in ten hours by the mixer. Its capacity may be less; it may work overtime to maintain the balance of supply with demand, but its capacity should be such that demurrage does not pile up unnecessarily due to erratic shipments, or delays caused to other plant units. Equipment standardized such as mixers now are, should not be overloaded. The machine may stand the strain for a time, but maintenance and depreciation charges will soon discount the apparent advantage. Workmanship suffers also.

Small and Large Jobs

After a road builder has bought his plant and completed a successful season's work, he has no assurance that his plant will balance with the requirements of the next job. There is an opportunity at times for the state and counties to adapt projects to plants. It has not always been possible to do this, however, because of considerations such as taking care of traffic during construction. It is sometimes advantageous to advertise a short job. A small job with a small organization and small overhead can compete favorably in unit price with a large job with

large organization and high overhead. The risk of delay is more costly in a large plant layout. The small plant layout has proven adaptable to a larger variety of jobs. It is true that the large plant may not have yet had the chance to demonstrate its worth due to the uncertainty of material supply. To date it is my opinion that the average net return on the money invested for the large plant has been lower for a season's run than with the small plant. The efficiency of the construction organization is responsible to a great degree for its success or failure. With improper equipment an efficient organization soon loses its efficiency and its interest in the welfare of the work.

Transportation Units—Light and Heavy Trucks

To return to the question of transportation units: With light truck haul, a light truck being considered 2-ton capacity or less, the truck makes up in speed what it lacks in capacity. Its use is favorable with comparatively short hauls, it is easier on the subgrade, parts are more readily replaced in case of breakdown, the time lapse is shorter after a rain for trucks to start running upon roads, and the interest charge on the capital invested is less. An apparent advantage is the fact that truck drivers may be obtained at cheaper rates than for heavy trucks, also mechanics, but how true ultimate costs will be cut is problematical. The investment of the owner in spare parts, however, is appreciably cut. With heavy trucks, on the other hand, a long haul is more advantageous. Due to the fact that for a given volume of haul a less number of heavy trucks are needed, they require less field supervision; there are fewer units on the road to pass each other, less time to load than in four or more light trucks, they are on the subgrade a shorter time in unloading the same volume, thus disturbing subgrader work less. The drivers take more personal pride in the performance of their heavy truck. In fixed charges the storage charge per heavy truck is less than for its capacity equivalent in light trucks. License fees are accordingly reduced. while risks on insurance, liability, fire and theft are less. The charge off for the life of heavy trucks can be taken as twice that of light trucks. Again in subletting truck hauls, it usually proves more satisfactory to sublet to heavy truck haulage concerns, as they are more substantial and trustworthy in general. There are evils in subletting truck hauls, however, due to the fact that the contractor loses his absolute control over his transportation units and condition of his subgrade. Trucks equipped with adequate tires for the capacity of the truck are essential as a remedy for subgrade troubles.

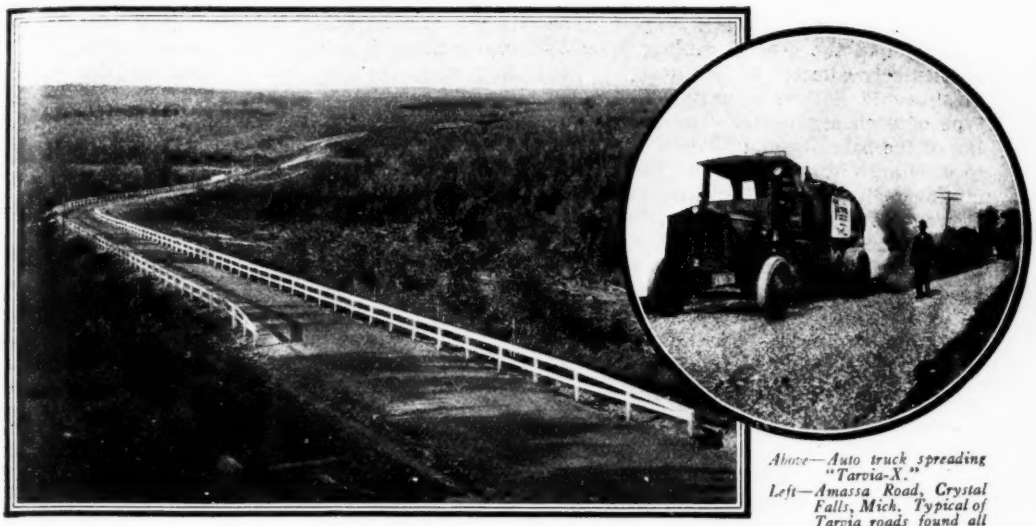
Industrial Railway Equipment

The heavy investment necessary for industrial railway equipment is warranted only on longer projects. Their layout and operation require close study in regard to soil conditions, weight of track, grades, booster engines, temporary and permanent passing switches, loading facilities and tracks using gravity wherever possible in favor of the load. Undoubtedly railroad economies can be profitably applied on some phases of its operation. It has been found that heavier loads should be drawn with the same power unit, or it is more economical to boost on heavy grade than it is to cut the load. Within the last two or three years the power unit has increased in weight and consequently increased the tractive effort with the necessary power. The 7½-ton gas locomotive and the 8x10-ton steam locomotive are preferred. The industrial haul is more reliable in general as a transportation unit than the truck method. The reliability of the industrial haul should lead to continuity of production. Against this advantage we must charge added interest and depreciation of plant investment.

In the comparison of the effectiveness and economy of any transportation unit, the cost per ton mile haul seems the logical basis for comparison. On a given project with a given output of the finished product the volume of material required in tons is constant. The mileage and time involved in hauling are the variable factors of the ton mile basis. We may decrease the tonnage per transportation unit and increase the speed of each unit, or vice versa, and obtain the same output within reasonable limits. The analysis of these factors for each project gives the builder the clew that he seeks as to the type to employ.

Central Mixing Plant

As previously stated in the plant layout, where the mixer does not operate on the subgrade, we are concerned with the so-called central mixing plant or a modification of it. In one case the mixer is fixed quite permanently; in the latter case the mixer can be shifted from stock pile to stock pile. The former must have materials brought to it; in the latter the



Above—Auto truck spreading "Tarvia-X."
Left—Amassa Road, Crystal Falls, Mich. Typical of Tarvia roads found all over the country.

The Country Wants Good Road *Mileage*—

"GOOD ROADS at *any cost*" is a mistaken policy. Good roads cease to be a benefit when the expense of building and maintaining them becomes burdensome. Costly construction slows up automatically the proper development of any good roads program.

What the country wants and needs is greater *mileage* of moderate-priced, low-maintenance all-year highways. Hundreds of towns and counties have found that Tarvia roads squarely meet this demand; that they are the economical solution of the good roads problem—satisfactory alike to road officials and taxpayers.

For Tarvia roads are not only firm, smooth, dustless and mudless all the year round—they are far less costly to build than any other type of modern highway, and far less costly to maintain. Because of these economies, the use of Tarvia insures the most miles of good roads that can possibly be built and maintained with the road funds available.

The granular surface of a properly constructed and properly maintained Tarvia road prevents skidding.

"Tarvia-X" is a dense coal-tar preparation which has been proved by experience to be the most durable bituminous binder for road construction. Other grades of Tarvia are made for preserving and patching all kinds of hard surface roads.

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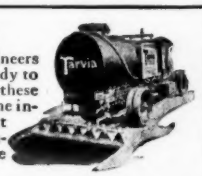
Special Service Department

This company has a corps of trained engineers and chemists who have given years of study to modern road problems. The advice of these men may be had for the asking by anyone interested. If you will write our nearest office regarding road problems and conditions in your vicinity, the matter will be given prompt attention.



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plant is more flexible in that respect. The operation of the central mixing plant is particularly affected by its design. The bins should deliver a uniformly graded type of each aggregate. The proportioning of the batch should be done just prior to discharge into the mixer. The central mixing plant layout centralizes activities. It would therefore cut supervision costs. This is not so true, however, of the modified type. The modified type might be used economically where heavy truck hauls are necessary to various stock piles along the road, with the soil conditions of the subgrade such that only light trucks could be used for hauling wet batch.

Many different types of portable elevators are now on the market for handling aggregates from stock pile to truck or industrial railroad that could be adapted to the modified central mixing plant.

Many specifications do not allow, others restrict the use of, concrete mixed by the central mixing plant method. Those that oppose its use contend that segregation of aggregates occurs in the concrete in its transportation, especially where long hauls are involved over rough roads. Truck haul is advisable, as by it individual batches are delivered to the project in the least time. Tests were made a year or more ago to determine the probable safe maximum haul of concrete mixed in a central mixing plant. The results as given in Public Roads, the former official publication of the United States Bureau of Public Roads, show in a general way the relative strength and consistency of gravel concrete when hauled in a wet batch and tested at various periods of time up to three hours after initial mixing. The concrete was mixed to a consistency to conform to a 2-in. slump with standard apparatus. Cylinder specimens were made for testing according to standard field practice. It is stated that the experiment indicates that the most practical way to utilize the central mixing plant in concrete road construction is in connection with a machine finisher. It also indicates that so long as the concrete is workable, after a period of hauling, the strength will not be affected. Further experimental work was to be conducted on the effectiveness of this method.

The Inundation Method

One of the more recent developments in the mixing of aggregates for concrete is the so-called "Inundation Method." It consists of measuring the sandaggregate in a container which has previously been partly filled with water in such quantity that when the container is level full the sand is completely soaked. The effect of moisture on sand is variable, depending upon the physical characteristics of the sand. Experiments show that the swell of dry sand measured after moistening by the addition of 2 per cent of water by weight may easily be 15 per cent. With like increments of water added, the volume tends to decrease to the saturation point. With a soaked sand, volume measurements become more constant. By this method the consistency of concrete can be more closely controlled. Experiments indicate that the compressive strength of concrete made of a given grading of aggregate varies inversely as the consistency of the mix. By the use of the inundation method of proportioning sand it may be possible to specify concrete by its strength rather than by its volumetric proportions. To my knowledge no practical adaptation has yet been made for using this method in actual construction, although there are no serious obstacles in the way of doing so.

The use of bulk cement has not been developed to the extent it could be. The standard sack of cement has been used so long in proportioning aggregates that the custom seems fixed. With storage bin facilities it is used successfully on both the central proportioning and central mixing plant types.

Curing

In the curing of the slab it is general practice to maintain moisture and temperature factors as near as may be at normal conditions. The top of the subgrade is kept moist, so that soil will absorb as little moisture from the concrete as possible. To retard evaporation and to reduce internal stresses, canvas canopies are placed over the concrete surface after finishing, or as soon as the concrete is sufficiently hard the surface is covered with water or moistened earth. These precautions make the rate of curing more uniform. The addition of reinforcement to the slab has no beneficial action in curing, as during contraction the steel has formed no bond with concrete.

Finishing

Considerable progress has been made in the development of the finishing machine. It is a labor saving device, and I might say a lifesaving device to humanely express its improvement over hand finish-

ing. By the use of such a machine a drier, consequently a stronger, concrete can be properly laid. The tamping action is particularly effective, tending to make a denser concrete and to flush grout to the surface for a smooth finish.

Design Details

The design of the pavement is not within the scope of this paper. There are certain details of design, however, that affect construction methods, not materially, but sufficiently to cause the builder some wonder as to how much work they will entail. I mention but a few of the most noteworthy developments. The central longitudinal point is generally placed to prevent a long crooked longitudinal crack. It is claimed that it increases about four times the beam strength of the half slab, acting as a beam. Steel dowel bars are placed transversely across the joint to act as tie-bars. The placing of the stiff dividing joint and the steel dowel bars in advance of the placing of concrete has not proven a drawback in the efficient prosecution of the work. Systems of steel reinforcement of the slab are now so fabricated that their placing above the subgrade does not interfere with other operations. The shape of the cross section on the bottom of the slab or the top of the subgrade has not been standardized. This detail works no particular hardships on the builder, however, as far as methods are concerned.

In regard to details of equipment some specifications require the use of steel side forms exclusively. This is quite necessary where a machine finisher is used. With the tendency towards concrete of firmer consistency, mixers are provided with accurate water gauging devices. Timing devices are also considered necessary. The boom and bucket system of distribution, after discharge from the mixer, is favored, as a drier mix can be used satisfactorily and segregation of aggregates prevented.

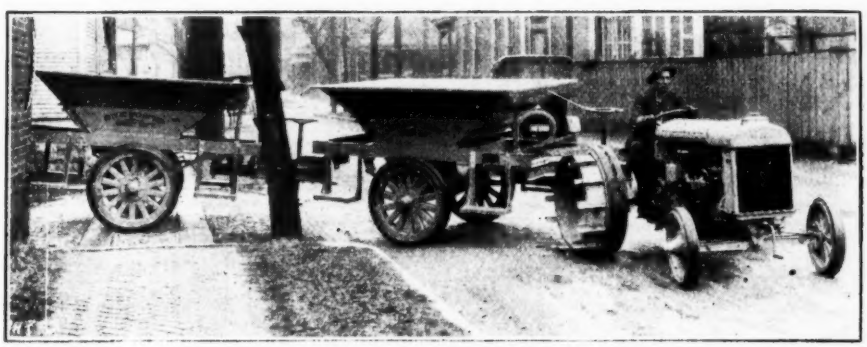
With the opening of the pavement to traffic the traveler is at once impressed with its riding qualities. The smoothness of finish, its freedom from uneveness are factors of prime importance to him, momentarily overshadowing the importance of the strength of the pavement. In specifications the limits of variation from a true surface are being drawn still closer. Expansion joints, where placed, must have their top edges truly flush with the adjacent concrete surface. Every detail of construction in fact is given painstaking care.

In conclusion a summation of the most striking developments that affect the methods used in this type of pavement would include the tendency towards the mechanical perfection of labor saving devices, plant co-ordination, security of material supply and large capital investments with a well trained and efficient organization.

The foregoing matter is from a paper presented at the Ninth Annual Michigan Conference on Highway Engineering at the University of Michigan.

MOTORIZED ASH COLLECTION AT RICHMOND, IND.

The equipment of eight Miami Fordson trailers and four Fordson tractors was purchased by the officials of the city of Richmond, Ind., through the Webb-Coleman Company, Ford dealers of that city. The transaction was completed by Mr. Paul James, sales manager of the Webb-Coleman Company, by actual demonstra-



ASH COLLECTION EQUIPMENT USED AT RICHMOND, IND.

tion of what the Miami trailer units would do when operated in trains with the Fordson tractor. They are pulling two trailers as shown in the illustration behind each tractor, through all the alleys for collecting ashes and rubbish of every description. The train is then pulled out onto the public dump where the load is quickly disposed of through the large rear doors in the trailers. These doors are controlled by two levers at the front of the trailers—one to dump the load, the other to rewind the doors.

The city is blocked off in four sections, two units being used in each section. Each tractor and train of two trailers is operated by three men—one to drive while the other two collect the ashes. This makes a continuous process for as soon as the first train is loaded—there is another train waiting for the loaders. The driver of the first unit goes to the dump at the rate of about seven miles per hour and is back again by the time the second unit is loaded.

In this manner each tractor and train of trailers replace two teams and two men, thus eliminating the old and costly method of two men riding on the wagon about half the day between the place the ashes are collected and the dump.

The capacity of each Miami dump trailer is 2½-tons, or 2 yds. rounded load, making a total load of the two trailers 5-tons, or 4 cu. yds. If at any time they should have occasion to use only one trailer, the second trailer may be dropped off at any point by simply operating the screw jack on the drawbar.

The city of Richmond, Ind., uses the eight trailers and four tractors for ash and trash collection in the winter time, but in the summer when this class of work is very light, it uses them for street repair or maintenance work. The city has its own sand and gravel pit from which it hauls gravel or sand for the unimproved streets.

The load can be spread evenly over the ground to any depth by simply adjusting the spreading device, or it can be dumped all in one spot as desired by the operator. In this manner the city officials have a complete unit which can be used the entire year for work as above described.

BIDS FOR ENGINEERING SERVICE

To the Editor:

The following advertisement is similar to several which have appeared in the technical press during the past two years:

"Bids wanted for engineering services for new water and light plant.

"Sealed proposals from experienced engineers will be received by the council of the city of ———— for preparing preliminary plans and specifications and furnishing estimates of the cost for a modern power plant. Such proposal to state experience and the applicant must furnish references and state amount of compensation for such service. The successful bidder will also be required to furnish a bond for such engineering service. All bids to be sealed and marked on the outside 'Bid for Engineering Service.' The right is reserved to reject any or all bids."

We would like to see a discussion of this problem in your columns in the hopes that possibly methods may be suggested which will tend to minimize the practice of calling for bids for professional services.

We have found that the governing bodies of municipalities advertising in this manner are interested mainly in the lowest bid received and only in a secondard ion in the reliability of the engineers they engage. This is particularly so when the engineer is asked to furnish a bond because it is hard for these authorities to see why a bond does not fully protect them and their taxpayers against inferior service and advice. In fact, we know of cases where towns have been particularly urged by engineers to call for competitive bids after their own particular proposition failed of acceptance. It seems to me that particularly all journals reaching public officials should discourage this procedure, pointing out that in reality they could afford best to employ the engineer who can command the highest prices instead of the one who will accept the lowest.

It is not necessary to state that on our part, we do not enter into competition of this sort on the basis of price but always put in our standard schedule. Is there not some way of protecting municipalities against the "cheap" engineer?

Very truly yours,

ARTHUR S. MILINOWSKI,

Of Druar & Milinowski, Consulting Engineers, Globe Bldg., St. Paul, Minn., Feb. 23, 1923.

Contracts Awarded

ROADS AND STREETS.

Ala., Centerville—G. C. Goodrich, Albany, Ala. awarded contract to grade, drain and surface with chert 20.164 miles of rd. btw. Centerville and Woodstock. Bibb County Proj. 120, at $200,215.

Ala., Anniston—J. F. Morgan Paving Co., Birmingham, Ala., awarded contract to pave, curb and gutter Wilmer Ave., 10th to 19th; Quintard, 18th to 22nd and Leighton, 5th to 22nd; asphalt on rolled base, at $92,020.

Ala., Luverne—Stanley & Singer, Lafayette, awarded contract at $114,000 for 20 miles Crenshaw Rd. and at $41,000 for bridge work.

Ark., Ft. Smith—Kaw Paving Co., Kansas City, Mo., awarded contr. to pave Dist. 3rd, at $146,093.

Cal., San Francisco—David H. Ryan, 1615 Fern St., San Diego, awarded contract by U. S. Bureau of Pub. Rds., for grading 10.9 miles of Adin to Adin Summit national forest hwy., at $92,855.

Cal., Los Angeles—Geo. H. Oswald, 366 E. 58th St., awarded contr. by Co. Supvrs. for improving Success Ave., w. bound. of city of Watts and Central Ave., 3,000 lin . ft. or .57 miles, at $28,000; Tryon & Brain, 201 Tajo Bldg., awarded contr. by Bd. Public Works, for paving portion Larchmont Blvd., at $175,696; Geo. H. Oswald, 366 E. 58th St., awarded contr. by Board Pub. Wks. for impvt. of Compton Ave., at $80,173; F. D. Baucus, contr. at $4,708 for improving portion of 93rd St.

Cal., Los Angeles—Utah Constr. Co., Phelen Bldg., San Francisco, awarded contr. by Union Pacific Ry.

Special Article Service

"If you don't see what you want, ask for it."

Thus the merchant to his customers; and thus, also, the editor to his readers.

Readers are invited to write the editor requesting that articles be published on subjects in which they are individually interested.

It is quite likely that each reader, while finding the magazine interesting as a whole, sometimes looks in vain for an article on some one subject of great and immediate interest to him. We can obtain and publish that article as easily as any other.

It is probable that articles so produced will be of value to others than the ones requesting their publication.

Tell us about it and we will do the rest.

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We have purchased 122,000 pairs of U. S. Army Munson last shoes, sizes 5½ to 12, which was the entire surplus stock of one of the largest U. S. Government shoe contractors.

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PROMPT DELIVERIES. LET US QUOTE YOU PRICES.

Co., 610 S. Main St., for grading industrial tract in vicinity of Belvedere Gardens, at $100,000.

Conn., Hartford—C. W. Blakeslee & Sons, Inc., 58 Waverly St., New Haven, awarded contract by State Hwy. Dept., for paving 19,470 ft. Shore Rd. in Guilford, plain and rein. conc., at $174,686 (cement to be furnished by the State.)

Ill., Springfield—Following contracts for paving let by Dept. Public Works and Buildings: 4.18 miles Dewitt Co. to L. S. Kuhn, Bloomington, Ill., at $109,444; 5.04, 3.95 and 2.37 miles in Rock Island Co., to Wm. O'Neil Sons Co., Fairbault, Minn., at $107,099, $81,343 and $54,151, respect.; 5.12 mi. Rock Isl. Co. to Henry W. Horst Co., Rock Island, Ill., at $117,960; 6.82 and 4.53 mi. in Grundy-Will and Grundy Cos., at $124,996 and $78,256 respect.; 1.66 mi. Whiteside Co. to Cook Co. Constr. Co., Chicago, Ill., at $37,350; 7.49 mi. Tazewell Co., to Hoffman & Small, Lincoln, Ill., at $153,790; 3.71 and 5.24 mi. in Perry and Perry-Franklin Cos., at $72,171 and $110,978; 3.22 and 3.35 mi., Wayne Co. to French Constr. Co., Fairfield, Ill., at $53,435 and $56,229 respect.; 7.99 and 5.85 mi., Marshall Co., to W. D. Longergan Constr. Co., New Madrid, Mo., at $137,243 and $105,788, respect.; 4.12 and 2.29 mi. Kendall Co., at $79,511 and $46,713, respect. to Trompeter & Sons, Peru, Ill.; 5.82, 5.98 and 5.70 mi., Iroquois-Ford, Iroquois and Iroquois Cos., at $104,369, $111,990 and $122,997 respect. to Chas. W. Clark C., Clinton, Ind.; 3.93 and 4.73 mi., Kankakee-Iroquois and Kankakee Cos., to Shanks & Cannon Constr. Co., Watseka, Ill., at $60,566 and $98,433 respect.; 2.92 mi. Knox Co., to L. S. Kuhn, Bloomington, Ill., at $56,450; 6.87 mi. in Franklin Co., at $118,276; 3.64 and 2.63 mi. Schuyler Co., at $85,852 and $61,556, respect., to Frank B. Rees, Quincy, Ill.; type for all sections is Portland cement concrete.

Ia., Dyersville—Dearborn Constr. Co., Waterloo, awarded contr. for paving, curbing, etc., at $149,795.

Ky., Earlington—Saether Roads Co., Birmingham, Ala., awarded contract for impvt. of various streets at $125,000.

La., Baton Rouge—Hampton Reynolds, New Orleans, awarded contract for grading, shell surfacing 6.12 miles Gulf Coast Hwy., from Rigelets to Sledell, St. Tammany Parish, FAP 126-A, at $121,208.

Mich., Lansing—Regan-Baker Co., Rexton, Mich., awarded contract for Rd. F. A. 80, C. & D., Mackinac Co., Garfield and Hudson Twps., Cl. B., 18 ft. wide, 7.804 mi. at $82,327; Rd. FA. 80, G, Mackinac Co., Brevoort Twp., Cl. V, 18 ft. wide, 5.254 mi. to S. J. Grooves & Sons Co., Duluth, Minn., at $52,359.

Mich., St. Ignace—Regan-Baker Co., Rexton, awarded cont. for road work on Secs. C and D, F. A. P. 801 Mackinac Co., at $82,327; grading, draining and gravel surf. 8 mi. road from Gilchrist to Rexton; Sec. G to S. J. Grooves & Son, 120 Manhattan Bldg., Duluth, at $52,369; grade, drain and gravel surface 6 mi. from Moran.

Mo., Independence—W. A. Ross, Kansas City, awarded cont. to pave 4 sections Sui-i-Bar road, Jackson Co., from Kansas City east, at $725,160.

Neb., W. Point—Roberts Constr. Co., 415 First National Bank Bldg., Lincoln, awarded cont. for impvt. of Dists. 2 and 3; 24,000 c.y. grading, 48,050 sq. yds. brk. on 4 and 5-in. base, 23,400 lin. ft. curb and gutter, 2,000 lin. ft. curb, 210 sidewalk approaches, 4,000 lin. ft. walks, at $184,891.

N. M., Santa Fe—Following contrs. awarded by State Hwy. Comn. with provision that State shall furnish culvert material for all projects except Proj. 82 on which contractor will furnish culvert material: No. 71, Chaves Co., 1,562 mi. to Jno. Mulligan, El Paso, Tex., at $18,788; No. 82, Lincoln Co., 16,067 mi., to H. E. Williams, El Paso, Tex., at $127,752; No. 89, Roosevelt Co., 1.989 mi., to J. F. Hamer, Ft. Worth, at $69,959; No. 92, Colfax Co., 10.320 mi. to Morrison & Morrison, Denver, at $69,976; No. 93, Colfax Co., 8.005 mi. to Morrison & Morrison, Denver, at $37,307; No. 103, Chaves Co., 9.927 mi., to Peterson, Shirley & Gunther, Omaha, Neb., at $51,919; No. 104, FAP, Sierra Co., 7.165 mi. to Jno. Mulligan, El Paso, at $58,965; No. 87, Hidalgo Co., 14.227 mi. to O. R. Smith, Denver, at $55,587. Each of the above amounts exclusive of 10% for engrg. and contingencies.

N. Y., Albany—Following contrs. let by State Hwy. Dept.: 2.89 mi. Hwy. Cayuga and Tompkins Cos., also 5.22 mi. Hwy. 8147, Part 2, Steuben Co., to Burd Constr. Co., Cresson, Pa., at $95,711 and $250,155, respect.; 0.41 mi. hwy. 5688, Bristol Center-Bloomfield Part 1-B, Ontario Co., to W. M. Bronk, Hudson Falls, at $20,056; 4.89 mi. Hwys. 8148 and 1644, Johnsonville-Buskirk Parts 1 and 2, Rensselaer Co., to S. B. Van Wagenen, Inc., Rondout, $167,512; 3.69 mi. Hwy. 1660 Mt. Ivy-Haverstraw, Rockland Co., to Colonial Contg. Co., Carlstadt, N. J. at $146,993; 5.51 mi. Hwy. 602 Ulster Co. to M. C. Tryon, Herkimer, at $169,537; reconstr. of 2.42 mi. Repair constr. 3043 Hwy. 447, Valley Falls-Johnsonville, Rensselaer Co., to Belmar Contg. Co., Inc., Troy, at $79,324.

N. Y., Brooklyn—Alcatraz Asphalt Co., 407 Hamilton Ave. awarded contr. for impvt. of Bay Parkway, 59th to 78th Sts., at $112,224.

N. C., Charlotte—Blythe Bros., Brevard Court, awarded contr. for grading and paving with asphalt and asph. conc. 13-14 miles streets; also conc. walks, at $700,000.

Ohio, Columbus—Dept. Hwys. & Pub. Wks. here let contracts for grading, bridging and paving 2.52 miles Sec. A and B, Solon, Willoughby and Chagrin Falls-Cuyahoga Falls Rd., Cuyahoga Co., Warrenite bitulithic, to Freshwater Const. Co., National Bldg., Cleveland, at $159,900; 1.49 mi. Sec. 1, 2.7 mi. Sec. J, 3.44 miles Sec. K, 1.8 mi., Sec. L and 1.39 mi. Sec. M, Cleveland-Massilon Rd., Summit Co., brick, to T. E. McShaffrey, Constr. Co., Forge St., Akron, at $75,912, $113,938, $155,762, $72,412 and $72,093, respect.

Okla., Oklahoma City—State Hwy. Comn. awarded contract for grading, paving and constructing bridges on 2 mi. Fed. Aid Proj. 90, Carter Co., 21,000 sq. yds. asph. rock, to Baum Constr. Co., Durant, at $31,400; Highway Constr. Co., Tulsa, awarded contr. for grading, paving and construction of bridges on 3.3 miles F. A. P. 93, Sec. A, Creek Co., 34.848 sq. yds. conc., at $84,755; grading and paving 6½ mi. Edmond Rd., Okla. Co., 48,000 c. y. earth excav., 69,700 sq. yds. vert. fibre brk. to Beekman Constr. Co., Coffeeville, Kansas, at $251,084; 3 miles Newcastle Rd., Okla. Co., 2,400 c. y. earth excav., 31,680 sq. yds. conc., to Green Constr. Co., 503 S. W. National Bank Bldg., Okla. City, at $106,000.

Ore., Portland—Following contrs. let by State Hwy. Dept.: Grading 8 miles Allen Ranch-Klamath Co. Line Sec. Unit 1, Dalles-California Hwy., Deschutes Co. to A. E. Doty, Portland, conc. pipe at $22,413; 6 miles Tygh Grade Sec., Dalles-California Hwy. Wasco Co., to Elliott, Scoggings and Pacquet, McKay Bldg., Portland, cast iron pipe, at $194,050; 3 miles Beach Crk. Sec. Ore. Caves Hwy. Josephine Co. to C. F. Rhodes Constr. Co., Medford, at $23,954; 8.67 mi. Unit 2, Crooked River-Deschutes Sec., Prineville-Lakeview Hwy. Crook Co., to Cook Co. Court, Prineville, corrugated galv. iron pipe, at $76,620; 3.3 mi. grading and surfacing, also 2.76 miles surfacing Pt. Oxford-Sixes River Sec., Roosevelt Coast Hwy., Curry Co. to J. Hakanson, Oakland, Cal., cedar log culverts, $49,425; 10.98 mi. grading and broken stone surfacing, Keno-Klamath Falls Sec., Ashland-Klamath Falls Hwy., Klamath Co. to Dunn & Baker, Klamath Falls, corrug. pipe, at $142,064; 9.83 mi. broken stone surfacing, Hayden Crk.-Jackson Co. line, Sec. Ashland-Klamath Falls Hwy., Klamath Co., Harness & Colby, Roseburg, at $62,750; brdg. 827 over Basket Slough, Holmes Gap-Rickreall Sec. West Side Hwy. Polk Co., to Oregon Constr. Co., Blake-McFall Bldg., Portland, at $53,373.

Penn., Ebensburg—Leechburg Constr. Co., Leechburg, awarded contract for 15,568 ft. brick hwy. bet. Cresson and Lilly, at $135,920.

Pa., Harrisburg—State Hwy. Dept. let contr. for 6,094 ft. Hempfield Twp. and Greenville Boro. 16 ft. Mercer Co. 10,916 sq. yds. rein. conc. and 3,994 c. y. unclassified excav. and 13,704 ft. Route 82, Sec. B, Hempfield and Sugar Grove Twps. Greenfield Boro. 18 ft. Mercer Co., 27,735 sq. yds. rein. conc. to M. Bennett & Sons, Indiana, at $45,656 and $132,400, respectively.

S. C.—Sumter—Powell Paving Co. Palmetto Bank Bldg., Coumbia, awarded contract for 15,000 sq. yds. sheet asph. paving, at $200,000.

Tenn., Nashville—Givens, Hobbe & Co., Marten, awarded contr. by State Hwy. Dept. for grading and surfacing with 8-in. cement conc., 9½ miles rd. from Humboldt to Trenton, Gibson Co., 18 ft.

at $302,870; bridges over 20 ft. span on above proj. to Little & Dean, Paris, at $9,980.

Tex., Bonham—J. C. Field & Co., Denison, awarded contr. by Fannin Co. for grading and rein. conc. paving on 5.66 mi. Hwy. 5, Honey Grove Dist. at $174,630.

Texas, Dallas—Miller Construction Co. awarded contract by Dallas County Commrs., to pave Bonnie View rd., at $69,066; Beckley road to Hill, Wilson & Watson Co., at $116,003.

Texas, Kaufman—F. P. McElwrath, Corsicana, Tex., awarded contr. to grade and construct draing. structs., on 10.74 miles S. H. No. 40, at $90,000.

Tex., Richmond—Hayden & Austin, 727 Kress Bldg., Houston, award. contract by Bend Co. for grading and surfacing 10.41 mi. State Hwy. 19, F.A.P. 318, at $123,910.

Va., Emporia—R. G. Lassiter & Co., Raleigh, N. C., awarded contract for 30,000 sq. yds. street paving at $100,000.

Wis., Fond du Lac—Jorgensen Constr. Co., Denmark, awarded contract for conc. surfacing, etc., on Fon du Lac-Calumetville Rd., at $118,627.

Wis., Elkhorn—Contracts let for following: Whitewater-Elkhorn Rd. to Fess & Fess, Madison, at $84,888; Elkhorn-Bunrlington Rd. to R. R. Birdsall, Racine, at $113,210.

Wis., Racine—J. R. Griffith, Racine, awarded contract for River Rd., impvt. Grading, surfacing, etc., at $91,015.

SEWERAGE AND SEWAGE TREATMENT

Cal., San Francisco—Clinton Constr. Co., 126 Townsend St., awarded contract for constr. of Army Street sewer extension, at $115,784.

Cal., Watts—J. G. Beckjord, 718 San Fernando Bldg., Los Angeles, awarded contract for constr. of City sewer system at $445,000.

Ont., Ottawa—Dominion Lock Joint Pipe Co., Harbor Commrs. Bldg., Toronto, have contract for pipe in sewers at $36,000.

Fla., Jacksonville—Bryan & Co., awarded contract for constr. of sewers at $38,800.

Ia., Clinton—W. B. Carter, 606 U. B. Bldg., Sioux City, awarded contract for storm and san. sewers in Dist. No. 7, at $49,879.

Ia., Glidden—Chapman Construction Co., Forest City, awarded contract for sewer, disposal plant, etc., at $40,744.

Kans., Pittsburg—Beeson Machinery Co., 308 Mutual Bldg., Kans. City, Mo., awarded contract for intercepting sewers, pumping station and sewage disp. plant, at $98,801.

Kans., Wichita—Foster & Skaer, Wichita, awarded contract for 4,160 ft. 30.66 in. segment blk. sewer, 8,275 ft. 12-27 in. D. S. tile sewer, 60 manholes, 103 inlets, 2,990 yds. paving, 1 outlet protection, 4,200 ft. walk removed and renewed in storm Sewer Dist. 24, at $85,410.

Ky., Louisville—J. H. Cahill, Louisville, awarded contract for 30th St. sewer at approx. $80,000; Howington Tirsway Co., Louisville, awarded contract for Mellwood Ave. sewers at approx. $50,000.

La., Homer—The Donathan Co., 422 Southern Trust Bldg., Little Rock, Ark., awarded contract for installation of complete sewer system, at approx. $100,000.

Md., Baltimore—Arundel Constr. Co., Knickerbocker Bldg., awarded contract for san. sewers in Dist. G-14, Contr. 198, at $73,502; Dist. 11, Contr. 197, to Shyrock & Rich, 4701 Reistertown Rd., at $61,063.

Mich., Detroit—Contract for 7,263 ft. Butternut St. arm, Clark Ave., sewer to J. A. Mercier, 216 Hammond Bldg., at $190,324; 3813 ft. Buchanan Ave. arm, Clark Ave. sewer, to G. R. Cooke, 1260 Penobscot Bldg., at $194,449.

Mo., Hamilton—C. H. Everott, Hutchinson, Kans., awarded contract for new sanitary sewerage system; 54,383 ft. trenching and backfilling, 54,293 ft. 8-12 in. vit., and 88 ft. 8 and 10 in. cast iron pipe, etc., at $93,000.

N. J., Newark—Culp Co., Inc., 412 E. 37th St., Paterson, awarded contract for local sewer connections in Carlisle Pl. Ogden. Passaic, 37th St., Paterson, at $109,829.

N. Y., Endicott—Endicott Johnson Corp., 198 E. Main St., will build large outfall sewerage system by day labor, under supervision of A. Beebe, Engr., care owner, $200,000.

N. Y., Syracuse—S. Palmisano, 305 Fulton St., awarded contract for constr. of 1st Ward sewer, 14 streets, 8-12 in. tile, at $34,965.

N. C., Charlotte—Tucker & Laxton, Realty Bldg., awarded contract for 8 miles sewers and drains, at $66,566.

Okla., Okla. City—Municipal Excavator Co., 200 E. Main St., awarded contract for 13,000 ft. sewers, at $41,656.

Okla, Tulsa—J. K. Roach, 1003 S. Quincy St., awarded contr. for constr. of conc. storm sewer in Dist. 51, S. Katy Relief, at $13,925; Comstock-Smedley, 432 Iowa Bldg., awarded contr. for sanitary sewers in Terrace, Regina and Ridgewood Sts., Dist. 189, at $42,953.

S. C., Clover—W. A. Ebert, Latta Arcade, Charlotte, N. C., awarded contract for constructing sewerage systems, at $53,064.

Tex., Brownsville—Kroeger & Hayner, Moore Bldg., San Antonio, awarded contract for complete disposal plant at about $50,034.

Va., Richmond—Smith Bros. awarded contract for No. Richmond trunk sewer and road laterals, at $500,000, Hull St. and Midlothian Turnpike, Porter, Holland, Bainbridge, Wise and vicinity of Atlantic Coast Line, Forest Hill, Nine Mile Rd., Fairfield and Chelsea Hill; A. E. Cheatwood, at $17,062, for Fulton Hill and Grace St. sewers.

WATER SUPPLY AND PURIFICATION

Ill., Chicago Heights—S. B. Geiger, 37 W. Van Buren St., Chicago, awarded contract for drilling 2,200 ft. artesian well at $39,076.

Kans., Alma—C. J. McCoy Constr. Co., Emporia, contr. for water works, including 30,360 ft. 2, 4 and 6 in. cast iron pipe; conc. reservoir, standpipe, etc., sewers, 8-10-12 in. vit. pipe; flush tanks, manhole, drop manholes, 12 in. c. i. pipe, etc. Totals $34,907 and $30,186, respectively.

La., Houma—Merkel Constr. Co., 1733 Walnut St., Kansas City, Mo., awarded contract for water works system, including struct. pipe laying, filtr. plant and power house, at $110,000; two 300-h.p. crude oil engines, with elec. equipt. to McIntosh-Seymour Corp., Auburn, N. Y., at $55,200.

Mass., Boston—Union Water Meter Co., awarded contract for furnishing water meters to Water Service, Pub. Wks. Dept., at $45,842.

Minn., St. Paul—St. Paul Foundry Co., Como Ave. and Mackubin St., awarded contract for castings and fittings for alum solution agitator for Water Dept., at $1,333; U. S. Cast Iron Pipe Co., Am. Trust Bldg., Birmingham, Ala., awarded contr. for 639 12-ft. lengths Cl. C, 1,626 12-ft. lengths Cl. B and 16 12-ft. lengths Cl. A spigot water pipe; also 2.644 tons miscel. pipe, at $440,000 (30 and 40 in. pipe contr. not awarded); 3,177 lbs. cast iron pipe, 2,803 lbs. miscl. steel to Valley Iron Wks., 85 E. Water St., $616; c. i. ladders, pipe railings, posts, bases, fittings flanges, channed stringers, etc., to St. Paul Foundry Co., Como Ave., and Mackubin St., at $1,800.

New York City—Bd. Water Supply, Municipal Bldg., awarded contract for gate valves and hydrants for Mt. Prospect Park Slope, Ft. Hamilton and Clove conduits and Narrows siphon 2 of Catskill Aqueduct. to Michigan Valve and Foundry Co., Detroit, Mich., at $224,320; Beaver Eng. & Contr. Co., 57 Chambers St., awarded contract for mains in Avenue A, 1st and 2nd Aves., E. 42nd and E. 81st Sts., at $134,738.

N. C., Charlotte—Lynchburg Foundry Co., Lynchburg, Va., awarded contract for furnishing 47,000 ft. cast iron pipe and fittings for extension of water works system, at $43,605.

Ohio, Cleveland—Gantose Constr. Co., Columbia Bldg., awarded contract for installing 31,800 ft. 6-10 in. cast iron mains in Impvt. 16B, Co. Water Dist. 2, at $66,112.

Ohio, Sandusky—Homberger & Wagar, Camp & Fillmore Sts., awarded contract by Erie County for 23,600 ft. 4 and 6 in. cast iron mains in Co. Sewer Dist. 2, at $66,112.

Okla., Guthrie—Municipal Excavator Co., 200 E. Main St., Okla. City, awarded contract for extension of water mains and sewers, at $15,972 and $17,419, respectively.

Okla., Morris—Sherman Mchy. & Iron Works, Okla. City, Okla., awarded contract for extension water works system, at $50,000; will construct $1,500,000 gal. plant, 50x100 ft., install 150 G. P. M.

motor (gas) centrifugal, one 400 G. P. M. motor driven centrifugal; construct approx. 10,000,000 gal. reservoir. Est. cost $30,000. H. G. Obenstead, Engr. Okla. City, Okla.

Okla., Tyrone—Ajax Construction Co., 1825 W. Main St., Okla. City, awarded contract for water works impvts., including drilling and casing two 12-in. wells, constructing 2 pump houses and derricks, two 60 to 75 gal. per min. deep well pumps, 2 250-gal. per min. motor driven centrifugal fire pumps complete with motors and controls, 150,000 gal. rein. conc. reservoir, one 30,000 gal. steel water tank on 80-ft. tower, rein. conc. and tile power house, cooling tower with conc. basin, machinery, tank and tower foundations, 2 panel switchboards, 924 ft. 8-in. 1,488 ft. 6-in. and 15,456 ft. 4-in. Cl. B cast iron pipe, 3,663 ft. 2-in. galv. pipe, 10,500 lbs. cast iron specials, etc., at $61,534.

Tenn., Memphis—Memphis Artesian Water Department let following contracts for machinery to be installed at plant at North Parkway: Auxiliary equipt. at $124,820, to M. J. Daugherty Co., Phila., Pa.; boiler settings at $15,950 to Rush Engrg. Co., Birmingham, Ala.; air meter at $13,600 to Cutler-Hammer Co., Milwaukee, Wis.

S. D., Rapids City—Water works reservoir contr. No. 1 let to Concrete Eng. Co., Rapid City, at $37,-752; laying pipe Contr. No. 2 to A. A. Dobson Co., 809 1st Nat'l Bank Bldg., Lincoln, Neb., at $26,753; c. i. pipe, Contr. 3, to DuLamel Co., Rapid City, at $89,505; lead and jute Contr. 4, and hydrants and valves, Contr. 5, to Hendrie & Bolthoff Co., 1639 17th St., Denver, Colo., at $6,119 and $6,354, respectively.

Tex., Dallas—Chicago Bridge & Iron Works, Praetorian Bldg., awarded contract for two 2,000,-000 gal. steel and conc. standpipes,, 60x100 ft.; one in Lakewood and the other in Belmont, at $51,300 and $51,900 respectively.

Tex., Highland Park—R. H. Dearing & Sons, Sumpter Bldg., Dallas, awarded contract for well, pumps, etc., at $100,000.

Tex., Quanah—Janes Constr. Co., Southwestern Life Bldg., Dallas, awarded contract for six mile pipe line and 50,000 gal. conc. reservoir, at $60,000; 2 pumping stations to L. Martin, Quanah, at $4,000.

Wis., Milwaukee—U. S. Cast Iron Pipe & Fdry. Co., 122 S. Mich. Ave., Chicago, awarded contract for furnishing cast iron pipe and castings at $134,-000; sluice gates and valves to Chapman Valve Mfg. Co., Indian Orchard, Mass., at $38,000; corp. curb & meter cocks and meter couplings to H. Hueller Mfg. Co., 517 Cerro Cordo St., Decatur, Ill., at $9,485; 6-in. gate valves to B. Hoffmann Mfg. Co., 257 6th St., at $4,300; fire hydrants to R. D. Wood, 2100 Locust St., Phila., at $15,350.

Prospective Work

ROAD AND STREETS

Ga., Waycross—Ware Co. Bond Comn., contemplates asph. surfacing 6 miles Alma Rd. of Dixie Hwy. from Manor toward Waycross; $60,000 Fed. aid available. County will furnish $60,000.

Ill., Sandwich—Bids will probably be asked in April for 4,200 linr. ft. rein. conc. pavement from 30 to 42 ft. in width. Arthur L. Webster, Wheaton, Ill. Cons. Engr.

Ia., Cedar Rapids—City will call for bids early in spring for 32 blocks vit. brick, fibre brick, asph., conc. or asph.-concrete. T. F. McCauley, City Engr. L. J. Storey, City Clk.

Ia., Cedar Rapids—City will call for bids about April 1st for approx. 10 blocks curb and gutter on First St. bet. 13th and Maple Dr. T. F. McCauley, City Clk.

Ia., Waterloo—City Council will probably ask bids about April for following proposed paving: 4.44 miles or 100,000 yds. new paving; 2.24 miles, or 40,000 yds. reconstruction of old pavements; 4.11 miles, or 58,000 yds. new paving under dist. plan of assessment. Total 10.80 miles or 198,000 yds. Ralph B. Shippy, City Engr.

Mich., Deckerville—Sanilac County plans to improve 8 county roads and 3 state roads. Following will be built by county; 7 miles west of Deckerville; road from Applegate to lake shore; one from Roseburg 6 miles east to Amadore; one-half mile in Croswell will finish Croswell-Peck road; one from pt. 7 miles east of Marlette to Village of Applegate; 1 mile through village of Forestville. There is some probability that Fed. Govt. will participate in this constr. State will build following: M-27 bet. Carsonville and Croswell, 13 miles north of Marlette on Earl Memorial Hwy., and road between Sandusky and Port Sanilac.

Mich., Grand Rapids—City Commission wil plrobabiy add 10 impvt., projects to 1923 program. Underwood Ave.—Aexander St. to Hall Sts.—will be paved on 10-yr. plan; Piett St.—Century Ave. to Clyde Park Rve., will be graded and paved on 5-yr. plan. Portions of Union, Benjamin, Jefferson, College, Frances and Lafayette Ave., will receive new surfacing on 1-yr. plan.

Mich., Marlette—Town plans expendt. of $117,-000 on street and sewer impvts, in 1923. This includes $45,000 which will be paid by State as its share in new pavements.

Neb., Omaha—City will pave 38 streets. Approx. 133 yds. paving, 59,000 yds. resurfacing and repaving. J. C. Dahlman, Mayor; Claude F. Bossle, Clk.

N. C., Raleigh—State Hwy. Dept. plans letting contracts in March to hard surf. 3 roads as follows: 7 mi. from Hickory Nut Gap to Bat Cave; 12 mi. from Canton to Waynesville; shale rd. from Hot Springs to Tenn. line. Mecklenburg Co. Hwy. Comn. plans expending $100,000 for 4 miles hard surf. road from 32nd St., in North Charlotte toward County Home and paving terminus of The Plaza; also will improve Derita rd. from Derita to city limits; binder material, $2,500.

Ore., Astoria—Three important highway impvt. projects will be undertaken by Clatsop Co. Court during coming spring: 5 mi. paving on main Nehalem Hwy., for which appropriation of $100,000 has been made; paving abt. 2 1-2 mi. on Young's River Fall. Hwy, paving to include 1 mile on west side of loop connecting up improved sects. there and 1 1-2 miles beginning at Olney and extending toward falls; paving of mile of Williamsport rd. along recently made fill from So. end of 7th St., to a connect. with main Nehalem Hwy.

S. C., Aiken—Aiken Co. Commrs. will pave highway bet. Aiken and Augusta with conc. and establish five toll gates. Proposed $300,000 bond issue.

S. D., Aberdeen—Petition filed for 67 blocks of paving here. Lydia W. Kohlhoff, City Clk.

S. D., Mitchell—Bids will be called for this spring for grading and surfacing F. A. P. 39 bet. Mitchell and Ethan, 12.25 miles, Davison County, J. B. Till, Co. Aud.

Tex., Clarksville—Red River County—Geo. Morrison, Co. Judge—plans bldg. 2 roads as follows: 9.33 miles on S. H. No. 5 from Bowie Co. line to Clarksville Rd., F. A. P. 311, $84,382; 5.74 miles gravel surf. rd. on S. H. No. 5, Bagwell rd. Dist., $56,700. J. B. Rieman, Co. Engr.

Tex., Highland Park—City contemplates improving 11 streets. $145,000 bond issue available. H. R. Davis, Mayor.

Tex., Houston—O. F. Holcomb, Mayor, plans to lay about 40 miles including 15 miles hard surface and 25 miles gravel and shell; White Oak Dr.—Milam St. to Houston Heights; Buffalo Bayou Dr.—Sam Houston Park across Waugh Dr. to Westheimer Rd.; Drive from Lamar Ave., through Sam Houston Park, to Buffalo Dr..; will also lay 2 miles hard surf. pavement on outer belt drive in Hermann Park and gravel circle drives through park.

Tex., Nacogdoches—City plans repaving business district as first step in paving program. Approx. cost $500,000.

Va., Suffolk—State Hwy. Comn.,—H. G. Shirley, Chrmn.—considering construction of 19 mile road bet. Carrsville and Suffolk. Est. cost, $260,000.

Wash., Centralia—Petitions presented to City Comn. for paving all streets in District bounded by Pearl, 1st and Main Sts.; also Washington Ave. Dist. comprises about 50 blocks.

Wash., Olympia—The Pacific Hwy. will be paved and opened for traffic bet. Toledo and Kalama by October 1st, unless plans of Hwy Div. miscarry. Legislature made an emergency appropriation of $1,670,000 for work and plans are now being com-

BUYERS' GUIDE

Aerial Tramways.
American Steel & Wire Co.

Air Lift Pumps.
Harris Air Pump Co.

Armor Plates.
Truscon Steel Co.

Asphalt.
Bitoslag Paving Co.
The Barrett Co.
Pioneer Asphalt Co.
Standard Oil Co. (Indiana)
The Texas Co.
Uvalde Asphalt Paving Co.
Warren Asphalt Paving Co., The

Asphalt Filler.
The Barrett Co.
Bitoslag Paving Co.
Standard Oil Co. (Indiana)
The Texas Co.
Warren Bros. Co.

Asphalt Floors.
The Barrett Co.
The Texas Co.
Warren Bros. Co.

Asphalt Machinery.
Cummer & Son Co., The F. D.

Asphalt Plants.
Austin Machinery Corporation.
Cummer & Son Co., The F. D.
Littleford Brothers.
Warren Bros. Co.

Asphalt Railroad Plants.
Cummer & Son Co., The F. D.
Warren Bros. Co.

Asphalt Tools.
Littleford Brothers.
Warren Bros. Co.

Asphalt Tool Wagons.
Littleford Brothers.

Auto Fire Apparatus.
Diamond T Motor Car Co.
Duplex Truck Co.
Garford Co., The.
Kissel Motor Car Co.
International Motor Co.
Lewis-Hall Iron Works.
Packard Motor Car Co.
Pierce-Arrow Motor Car Co.

Back Fillers.
Austin Machinery Corporation.
Pawling & Harnischfeger.

Bar Cutters and Benders.
Koehring Machine Co.

Bars, Reinforcing.
Truscon Steel Co.

Binders, Road.
The Barrett Co.
Pioneer Asphalt Co.
Standard Oil Co. (Indiana)
The Texas Co.
Uvalde Asphalt Paving Co.
Warren Bros. Co.

Bitulithic Pavements.
Warren Bros Co.

Blasting Accessories.
E. I. du Pont de Nemours & Co., Inc.

Blasting Powder.
E. I. du Pont de Nemours & Co., Inc.

Bodies.
Lee Trailer and Body Co.
Littleford Brothers.

Braces, Extension.
Kalamazoo Fdy. & Machine Co.

Brick Rattlers.
Olsen & Co., Tinius.

Brick-Testing Machinery.
Tinius Olsen Testing Mach. Co.

Bridges.
Lewis-Hall Iron Works.

Buckets, Dredging, Excavating and Sewer.
Pawling & Harnischfeger.

Buckets, Dumping.
Littleford Brothers.
Pawling & Harnischfeger.

Cableway Accessories.
Sauerman Bros.

Cableway Excavators.
Sauerman Bros.

Calculators.
Kolesch & Co.

Car Unloaders.
Austin Machinery Corporation.
Heltzel Steel Form & Iron Co.

Castings.
U. S. Cast Iron Pipe & Fdy. Co.

Cast Iron Pipe.
U. S. Cast Iron Pipe & Fdy. Co.

Catchbasins.
Dee Co., Wm. E.
Madison Foundry Co.

Cement Testing.
Kirschbraun, Lester.

Cement Testing Machinery.
Tinius Olsen Testing Mach. Co.

Central Heating Plants.
American District Steam Co.

Chimneys, Concrete.
Truscon Steel Co.

Chimneys, Steel.
Lewis-Hall Iron Works.
Littleford Brothers.

Chloride of Lime.
Pennsylvania Salt Mfg. Co.

Chutes, Concrete.
Heltzel Steel Form & Iron Co.
Littleford Brothers.

Concrete Mixers.
Austin Machinery Corporation.
Koehring Machine Co.
Smith Co., T. L., The

Concrete, Reinforcement.
American Steel & Wire Co.
Truscon Steel Co.

Conduits.
Cannelton Sewer Pipe Co.
Carey Co., Philip, The.
Truscon Steel Co.

Conduit Rods.
Stewart, W. H.

Conduits, Wood, Creosoted.
Republic Creosoting Co.

Consulting Engineers.
Alvord, John W.
American Appraisal Co.
Artingstall, Wm.
Brossman, Chas.
Burd & Giffels.
Chicago Paving Laboratory.
City Wastes Disposal Co.
Dow & Smith.
Fargo Engineering Co.
Flood, Walter H., & Co.
Gannett, Seelye & Fleming Co.
Hill, Nicholas S., Jr.,
Howard, J. W.
Hunt & Co., Robert W.
Jones, Sam L.
Kirchoffer, W. G.
Kirschbraun, Lester.
Luten, Daniel B.
Morse, Wm. F.
Potter, Alexander.
Van Trump, Isaac.
Wells, James P.

Contractors.
City Wastes Disposal Co.
Sullivan, Long & Hagerty.
Warren Bros. Co.

Contractors' Tools and Machinery.
Austin Machinery Corporation.
Austin-Western Road Machinery Co.
Good Roads Machinery Co., Inc.
Koehring Machine Co.
Littleford Bros.
Smith Co., T. L., The

Contractors' Wagons.
Austin Machinery Corporation.
Austin-Western Road Machinery Co.

Conveying Machinery.
Mead-Morrison Mfg. Co.
Pawling & Harnischfeger.
Portable Machinery Co., Inc.
Webster Mfg. Co.

Cranes and Hoists.
Austin Machinery Corporation.
Heltzel Steel Form & Iron Co.
Pawling & Harnischfeger.

Creosote.
The Barrett Co.
Republic Creosoting Co.

Creosoted Wood Block.
(Factory Floors, Bridge Floors)
Republic Creosoting Co.

Crushers, Rock and Ore.
Austin-Western Road Machinery Co.
Good Roads Machinery Co., Inc.

Culvert Pipe, Vitrified.
Cannelton Pipe Co.
Dee Clay Mfg. Co., Wm. E.

Culverts.
Austin-Western Road Machinery Co.
Newport Culvert Co.
Truscon Steel Co.

Curb and Gutter Forms.
Heltzel Steel Form & Iron Co.
Truscon Steel Co.

Curb Bar.
Truscon Steel Co.

Direct Oxidation Process.
Direct Oxidation Process Corp.

Disinfectants.
Integrity Chemical Co.

Drag-Line Excavators.
Austin Machinery Corporation.

Drag Scrapers.
Austin-Western Road Machinery Co.

Drain Tile.
Dee Clay Mfg Co., W. E.

Drawing Materials.
Kolesch & Co.

Dryers.
Cummer & Son., The F. D.

Dump Cars.
Austin-Western Road Machinery Co.

Dump Wagons.
Austin-Western Road Machinery Co.

pleted. On March 13th the first of the paving contracts will be let, the work being 4.5 miles bet. Kalama and Carrolls and 6.7 miles bet. Carrolls and Kelso, both of which must be finished by Aug. 15. It is expected the work will cost about $400,000; on March 27 contracts will be let for 6.3 miles paving from Kelso No. and 4.6 miles from Castle Rock So., the two jobs to cost about $350,000 and to be finished by Sept. 1. Contracts will be let April 10th for 4.7 miles paving from Castle Rock No.; 5.8 miles from Loughlin's Mouth No., and 4.8 miles from Toledo So. This is est. to cost $500,000 and will be finished by Sept. 1. An overhead brdg. at Kelso will be included in one of the hwy. contracts. To be let later will be contracts for bridges bet. Centralia and Chehalis, and another across Salmon Creek, So. of Toledo, Lewis Co. It is expected the $200,000 conc. bridge at La Center will be started this summer. It will be 1,100 ft. long and provided with walks.

Wash., Seattle—White Center Dist. and territory bet. White Ctr. and Lake Burien, will be opened up is not far distant future with paved arterial hwy. 20 ft. in width. King Co. and city will join in construction. Plans being prepared by City Engr. and King Co. Engr. Thos R. Beeman for a portion of which will eventually be hard surfaced rdway. from Riverside to Lake Buren. Asst. City Engr. Tiedeman stated it is planned to call for bids early in spring for prelim. work in connection with paving with 7-in. 20-ft. conc. by city of 3 miles of what is known as old McKinnon rd. Paving contemplated by City Engr. Dept., will represent expendt. of approx. $75,000, which amount would have to be duplicated for grading work and relocating portions of hwy., making city's cost $150,000.

W. Va., Fairmount—Marion Co., Winfield Dist., plans to build Morgantown pike betw. Fairmount and Morgantown through district. Will vote in March on $200,000. Frank J. Wilfong, Co. Rd. Engr.

W. Va., South Charleston Branch—(Charleston) City will pave streets and lay sidewalks. $177,500 bonds voted.

SEWERAGE AND SEWAGE TREATMENT

Cal., Centerville—Union Sanitary District soon to receive bids on 52,000 lin. ft. of 6-14 in. ironstone vit. sewer pipe. $75,000 bonds have been sold for the impvt. G. Posey, Court House, Oakland, Engr.

Cal., Hollister—Constr. of sewage disp. plant planned. Est. cost $25,000. C. F. Smith, 7 Nottingham St., Berkeley, Engr.

Cal., Los Angeles—City Engr. Jno. Griffin has been instructed by Council to negotiate with Pacific Elec. Ry., for right-of-way along line of proposed subway to Vineyard for new Arroyo de la Sacatella sewer sys. Engineer will draft new plans for sewer line as soon as this phase of work is completed.

Cal., Newport Beach—Plans and specfs. prepared for complete sewer system for Balboa Island, including Imhoff septic tank disp. sys. by Paul E. Kressly, Cons. Engr. 732 N. W. Hellman Bldg., Los Angeles.

B. C., Nelson—Council has approved sewer construction to extent of $56,000. W. E. Wasson, City Clerk.

Ont., Ft. Erie—$50,000 bonds voted for extension of sewers, including pumping plant and force mains. Prices wanted on material and equipment. T. M. Dodds, Engr.

Ont., Owen Sound—Plans being prepared for 6,000 to 7,000 ft. vit. tile san. sewers in various streets, 8-in. up. Est. cost $70,000. D. H. Fleming, City Engineer.

Ont., Sandwich—Plans being prepared for sewage disposal plant. Est. cost $150,000. McMoll & Patterson, Gas Bldg., Windsor, Engrs.

Conn., Bridgeport—Plans being prepared for storm sewer in Lindley St., Hawley Ave., and intersecting streets. Est. cost $80,000; Beechwood Park sect., sect. No. of North Ave., on Laurel and Park Aves., and emptying into Rooster River, $75,000; E. Main and Hickory Sts., Forest Sq. and Minnesota Ave., $55,000, Bethany Chapel Sec. No. Main St., etc., $30,000; Laurel Ave.—Arlington to Cleveland Aves., $20,000; trunk line storm sewer in Gilman St., $30,000; Capitol Ave., $25,000; comb. storm and san. sewers in Maplewood Ave.—Colo. Ave. to Dewey St., through Dewey St. into Ash Creek, $40,000; Grand St., from Grand and Oak Sts., to No. Washington Ave. and Grand Sts., $45,000; Wayne St.—$30,000; Grant St., Clairmount and Boston Aves. and Mill Hill trunk sewer in Mt. Grove St., from Dewey to Bostwick, emptying into Bostwick Ave. trunk system, $60,000. J. E. McElray, City Hall, City Engr.

Fla., Miami—It is proposed to construct a storm and san. sewer in Westmoreland Section and 12th Ave. Dist. Est. cost $150,000. C. W. Murray, Direct. Public Works.

Ga., Douglas—City having surveys and ests prepared on approximately 1 mile trunk line sewer to be installed in near future.

Ill., Lewistown—Plans being made for 2 miles san. sewerage system, including disp. plant, in Sewer Dist. 2. $40,000. W. A. Fuller Co. 1917 Ry. Exchange St. St. Louis, Mo., Engrs.

Ia., Anamosa—Plans being made for disp. plant here. Cons. Engrs., Lafayette Tiggins & Sons, 420 Security Bldg., Des Moines. Daisy Stevens, City Clerk.

Ky., Owensboro—City will probably vote on $650,000 bonds for sewer constr. J. R. Nickam, Mayor.

Md., Baltimore—City will construct san. sewer in Tiffany Run from Millen Rd. to Arlington Ave. Est. cost $200,000; also plans to construct san. sewer in Stony Run Valley bet. York Rd., and Roland Ave. Aug. E. Christhilf, Chief Engr.

Mass., West Springfield—Plans under way for large sewer in Merrick Section. Est. cost $100,000. Steele Bros., Elm st., Engrs.

Mich., Jackson—Plans being prepared for sewage disposal plant, intercepting relief sewers and water systems. Est. cost $350,000. Hoad, Decker, Shoecraft & Drury, 302 So. State St., Ann Arbor, Engrs.

Minn., Minneapolis—Sewer construction planned here, $785,000; also work on Minnehaha Creek trunk sewer; $192,000. Work will be done by day labor. City Purch. Dept. soon to take bids on materials.

Mo., Harrisonville—Village voted to issue $60,000 bonds for san. sewerage system. W. R. Rollins & Co., 521 Ry. Exchange Bldg., Kans. City, Engrs.

Mo., Richmond—$60,000 bonds voted for sewers. J. W. Kirkpatrick, Clerk.

Mo., St. Louis—$11,000,000 bonds voted for River Des Peres sewerage impvts. and $8,000,000 for sewer construction.

Neb., Humboldt—City considering constr. of sewers in residential district. Wm. Lydick, City Clerk. Est. cost $30,000.

Neb., Omaha—City will soon receive bids for storm sewers in Grace St.—8th to 15th Sts.; 11th and Grace to 13th and Locust Sts., $250,000; exten. to Saddle Creek storm sewer west to 50th St., $50,000; Mud Creek storm sewer from A to G Sts., So. Omaha, $125,000; exten. to Minne Lusa storm sewer to 23rd, $250,000; storm sewer from 30th and Weber Sts. to Jct. with Minne Lusa sewer, $100,000; Benson sewer No. West from 63rd St. and Military Ave., $125,000. H. Beal, City Hall, Engr.

N. J., Trenton—Will soon take bids on sewage disposal plant. Est. cost $1,250,000. G. A. Johnson, 150 Nassau St., New York City, Engr.

N. Y., Brighton—Towns of Brighton and Pittsford having plans prepared for 40 miles of sewers and sewage disposal plant. Est. cost of impvts., $1,265,000. W. S. Lozier, 321 Cutler Bldg., Rochester.

N. Y., Endicott—Endicott Johnson Corp. 198 E. Main St., considering building trunk outfall sewer in W. Endicott for factory and home development. $200,000. Hoadley & Giles, Engr., Care owners.

N. Y., Oneida—Plans prepared and bids will be taken about May 1st for sewage disp. plant, including Imhoff tanks, pumping plant; 1,350 lin. ft. ings or new connections and additional mains in Hayes-Barton and Oberlin sections. $93,000. J. B. Bray, Commr. of Public Wks.

Ohio, Akron—Plans canal interceptor from Market St. to Cuyahoga River. $62,500. J. E. Root, Delaware Bldg., Engr.

Penn., Erie—City will take bids about April 1st for construction of new intercepting sewer system.

Tenn., Dayton—Town considering construction of sewerage system. Est. cost $50,000.

Tex., Brownsville—City will soon take bids on complete sewage disposal plant. Est. cost $75,000. H. E. Snow, City Engr.

Tex., Macona—City Commission will soon take bids on san. sewers in various streets. $50,000. Elrod Engineering Co., 3206 Elm St., Dallas, Engrs.

BUYERS' GUIDE

Dust Laying Compound.
The Barrett Co.
Standard Oil Co. (Indiana)
The Texas Co.

Dynamite.
E. I. du Pont de Nemours & Co., Inc.

Edge Protector.
Truscon Steel Co.

Electrical Wires & Cables.
American Steel & Wire Co.

Elevating Graders.
Austin-Western Road Machinery Co.

Elevators.
C. H. & E. Mfg. Co.

Engineering Instruments.
Kolesch & Co.
Lufkin Rule Co., The

Engines.
C. H. & E. Mfg. Co.

Excavating Machinery.
F. C. Austin Machinery Co.
Pawling & Harnischfeger.
Sauerman Bros.
Smith Co., T. L., The

Expansion Joint Compound.
The Barrett Co.
Carey Co., Philip, The
Pioneer Asphalt Co.
Truscon Steel Co.

Explosives.
E. I. du Pont de Nemours & Co.

Fence, Iron.
Cincinnati Iron Fence Co.

Fillers (Paving Joint).
The Barrett Co.
Carey Co., Philip, The.
Pioneer Asphalt Co.
The Texas Co.

Fire Brick.
Cannelton Sewer Pipe Co.
Dee Clay Mfg. Co., W. E.

Flue Liners.
Cannelton Sewer Pipe Co.
Dee Clay Mfg. Co., W. E.

Forms, Sidewalks, Curb & Gutter.
Heltzel Steel Form & Iron Co.
Truscon Steel Co.

Forms, Road.
Heltzel Steel Form & Iron Co.
Truscon Steel Co.

Forms (Sewers & Conduits).
Heltzel Steel Form & Iron Co.

Forms (Wall Bldg., Construction, Etc.).
Heltzel Steel Form & Iron Co.

Gas Pipe.
U. S. Cast Iron Pipe & Fdy. Co.

Graders.
Austin-Western Road Machin-
Good Roads Machinery Co., Inc.
ery Co.

Granite Block.
Granite Paving Block Mfrs. Assn. of the U. S., Inc.

Gravel Screener and Loader.
Good Roads Machinery Co., Inc.
Jordan & Steele Mfg. Co., Inc.

Heaters (Rock and Sand).
Littleford Bros.

Heating Plants, Central.
American District Steam Co.

Heating Wagons (Oil and Tar).
Good Roads Machinery Co., Inc.
Littleford Bros.

Hoists (Concrete, Gasoline and Hand).
Pawling & Harnischfeger.

Hoists, Electric .
Mead-Morrison Mfg. Co.
Pawling & Harnischfeger.

Hoists, Steam.
C. H. & E. Mfg. Co.
Lewis-Hall Iron Works.
Mead-Morrison Mfg. Co.

Hot Mixers.
F. C. Austin Machinery Co.

Hydrants.
The Flower Company.

Incinerators.
William F. Morse.

Inlets (Sewer).
Dee Co., Wm. E.
Madison Foundry Co.

Insulating Material.
The Barrett Co.
Pioneer Asphalt Co.

Joint Fillers (Paving).
The Barrett Co.
Carey Co., Philip, The.
The Texas Company.

Kettles (Portable).
Cummer & Son Co., The F. D.
Good Roads Machinery Co., Inc.
Littleford Brothers.

Loaders.
Brown Portable Conveying Machinery Co.

Manhole Covers.
Madison Foundry Co.
Dee Co., Wm. E.

Mastic.
The Barrett Co.
Pioneer Asphalt Co.

Meter Boxes.
McNutt Meter Box Co.

Mixers, Asphalt.
Austin Machinery Corporation.
Cummer & Sons Co., The F. D.

Mixers, Concrete.
Austin Machinery Corporation.
Koehring Machine Co.
T. L. Smith Co.

Mixers—Mortar.
C. H. & E. Mfg. Co.

Molds (Pipe & Culvert).
Heltzel Steel Form & Iron Co.

Motor Fire Apparatus.
Acme Motor Truck Co.
Duplex Truck Co.
Federal Motor Truck Co.
Garford Motor Truck Co.
International Motor Co.
Kissel Motor Car Co.
Lewis-Hall Iron Works.
Packard Motor Car Co.
Pierce-Arrow Motor Car Co.

Motor Trucks.
Acme Motor Truck Co.
Duplex Truck Co.
Federal Motor Truck Co.
International Motor Co.
Kissel Motor Car Co.
Lewis-Hall Iron Works.
Packard Motor Car Co.
Pierce-Arrow Motor Car Co.

Motor Truck Flushers, Sprinklers and Oilers.
Acme Motor Truck Co.
Austin Machinery Corporation.
Duplex Truck Co.
Federal Motor Truck Co.
Garford Motor Truck Co.
The Gramm-Bernstein Motor Truck Co.
International Motor Co.
Kissel Motor Car Co.
Lewis-Hall Iron Works.
Packard Motor Car Co.
Pierce-Arrow Motor Car Co.

Municipal Castings.
Dee Co., Wm. E.
Madison Foundry.

Packing.
Pioneer Asphalt Co.

Paints (Asphalt).
Barrett Co., The
Pioneer Asphalt Co.

Paving Blocks (Creosoted).
The Barrett Co.
Republic Creosoting Co.

Paving Brick.
Medal Paving Brick Co.
Metropolitan Paving Brick Co.
Murphysboro Paving Brick Co.
National Paving Brick Mfrs. Assn.
Springfield Paving Brick Co.

Paving Contractors.
Warren Bros. Co.

Paving Joint Compound.
The Barrett Co.
Carey Co., Philip, The.
Pioneer Asphalt Co.
The Texas Company.

Paving Joint Filler.
The Barrett Co.
Carey Co., Philip, The.
Pioneer Asphalt Co.
The Texas Company.

Paving Machines.
Austin Machinery Corporation.
Cummer & Son Co., The F. D.
East Iron & Machine Co., The
Warren Bros. Co.

Paving Plants (Asphalt).
Austin Machinery Corporation.
Cummer & Son., The F. D.
East Iron & Machine Co., The
Good Roads Machinery Co., Inc.
Smith Co., T. L., The
Warren Bros. Co.

Pipe Cutters.
W. W. Stickler & Bros.

Pipe Dip and Coatings.
The Barrett Co.
Pioneer Asphalt Co.
The Texas Co.

Pipe Manufacturers.
U. S. Cast Iron Pipe & Fdy. Co.

Pitch Filler.
The Barrett Co.
Warren Bros. Co.

Plows (Rooter and Wing).
Austin-Western Road Mach. Co.

Portable Paving Plants.
Austin Machinery Corporation.
Cummer & Son Co., The F. D.
Good Roads Machinery Co., Inc.
Littleford Brothers.
Warren Bros. Co.

Portable Stone Bins.
Austin-Western Road Machinery Co.
Good Roads Machinery Co., Inc.

Powder (Blasting).
E. I. du Pont de Nemours & Co., Inc.

Tex., Rosenberg—$50,000 bonds voted here for san. sewer impvts., including sewage disposal plant. E. E. Sands, City Hall, Houston, Constr. Engr.

Tex., Seymour—City will expend $16,000 for sewer extension and $25,000 for water works extension. R. G. Garrisway Co., Engr. in charge.

Utah, Ogden—City Comn. will take bids early in spring for 8-16 in. vit. clay sanitary sewers in vicinity of Five Points Dist. Est. cost $75,000. W. S. Craven, City Engr.

Va., Norfolk—City Council approved Ord., extending Kensington drain from 39th to 42nd Sts. Approx. cost $36,000.

Wis., Milwaukee—City will call for bids on following: (a) Sewer in Scott St., 48 in. conc. and c: i. Est. cost $600,000; (b) Sewer in Okla. Ave., 42 in. conc. Est. cost $125,000; (c) Completion of Syphons at Park St. dual sewer of iron and conc., $30,000; (d) 1,656 tons iron, $82,000; also sluice gate and gate valves for disp. plant on Jones Island, $60,000. W. E. Chase, City Clerk.

Wis., New London—Will probably take bids in March for Oshkosh St. sewer dist. About 2 miles pipe. H. R. Albert, Engr., Court House, Green Bay, City Clerk. C. J. Thompson.

Wis., Superior—Sewer main from 58th St. and Hughitt Ave., to Nemidji River is being considered. Est. cost, $50,000. E. E. Banks, City Engr. F. A. Baxter, City Clerk.

Wis., Woodville—Plans being prepared for sanitary sewerage system here, to cost $30,000. Druar & Milinowski, 500 Globe Bldg., St. Paul, Engrs.

WATER SUPPLY AND PURIFICATION

Cal., Antioch—Plans being prepared for impvt. of water works, including 500,000 gal. rein. conc. settling basin, 100,000 coagulation basin, cast iron outside piping, repairing present filtr. sys. and installing 2 pumps. C. F. Smith, 7 Nottingham Et., Berkeley, Engr.

Cal., Oakdale—Oakdale and So. San Joaquin Irrig. Dists., plan election to vote on $3,750,000 bonds for Melones Reservoir and power house.

Cal., San Diego—Election April 3rd to vote on $400,000 bond issue for auxiliary woodstave pipe line betw. Lower Otay reservoir and City water system. F. A. Rhodes, City Engr.

Cal., Santa Cruz—City will vote on $325,000 bond issue for water works system. J. K. James, City Engineer.

Ont., Belleville—Plans being prepared for filtration system. Est. cost. $150,000. Gore, Nasmith & Storrie, Conferation Life Bldg., Toronto, Engrs.

B. C., Hanover—Plans and specfs. for mechanical gravity water filtration plant, to cost approx. $150,000, are being prepared.

Ont., London—Application to City Council will be made by Utilities Comn., for permission to issue debentures to extent of $75,000 for purchase of 5,000 water meters which are to be installed this year.

Que., Montreal—City plans to expend $1,000,000 for impvts. to city aqueduct system, chiefly reservoir and filtration basins. H. A. Terreault, Director Public Works, Engr.

Ont., No. York Twp.—James, Proctor & Redfern, Toronto, preparing plans for a $125,000 water works plant for the Township.

Ont., Toronto—Commr. of Works, R. C. Harris, has included in his 1923 estimates $665,000 for sewage, disp. work, repairs and relief sewers; high pressure fire service mains, costing $709,000 and water works totaling $2,000,000. An additional pumping and steam plant and 2 pumps of 25,000,000 and 80,000,000 gal. capy., are included.

Conn., Meriden—Health and Water Dept. contemplate constructing filtration plant. Est. cost, $75,000. Engineer not selected.

Ill., McLeansboro—Plans being made for water works including impounding reservoir, rapid sand filter plant, dam, several miles pipe lines, new engines and generators. W. A. Fuller, 1917 Ry. Exch. Bldg., St. Louis, Mo., Engr.

Mass., Marblehead—Permission will be requested of Legislature by town for bond issue in sum of $200,000 for extensions to water works system. Proposed impvts. include new standpipe, additional filter beds and several miles of new mains.

Minn., Lake City—E. L. Burghart, City Clerk, will ask bids to close about April 1st. Louis P. Wolff, 1000 Guardian Life Bldg., St. Paul. Est. cost $160,000. Work will include sanitary, storm sewers aand water main extensions.

Mo., Holden—City will make extensive impvts. to water works system. It is contemplated rebuilding present dam, increasing water supply, providing for modern water filter, plant and new pumpg. sta., constructing additional water mains in city and providing for new elevated tank. Benham Engrg. Co. Cons. Engrs. Kans. City, Mo., retained to make report on proposed work. Soon as report is filed Council will call election.

Mo., Kirkwood—$105,000 bonds voted for constr. of water line from Meramee River, Postoffice for Kirkwood is St. Louis.

N. J., Asbury—Adequate water supply imperative and it is proposed to expend $100,000 on exten. and general impvt. of city water system.

N. Y., Huntington, L. I.—It is planned to expend $150,000 for impvts. to water supply.

N. Y., Savannah—$45,000 water bonds sold and options taken on proposed site for water system.

N. C., Concord—City considering enlarging present water supply, including small dam, pumps, pipe lines, etc., $200,000. W. H. Booker, of Mees & Mees, Cons. Engrs., Kinney Bldg., Charlotte, Engr.

Ohio. Cleveland—City plans $100,000,000 gal. reservoir, Bean and York Rds., Parma Twp. Est. cost $1,300,000. A. V. Ruggles, City Hall, Engr.

Okla., Depew—Plans being prepared for pumping station, water mains and sewerage system. $50,000 bonds sold. Gantt & Baker, 1st National Bank Bldg., Okla. City, Cons. Engrs.

Okla., Poteau—J. E. Davis, Cons. Engr. on proposed $45,000 water works impvts., for which bonds have been voted. Earl Wyatt, City Clk.

Okla., Roosevelt—City will construct earthen dam and reservoir with capy. of 30,000,000 gals., filtr. plant and pumping stations. Est. cost $300,000. V. V. Long & Co., Engrs., 1300 Colcord Bldg., Okla. City.

Okla., Woodward—City will soon advertise for bids on water plant and distribution system. Est. cost $170,000. Black & Veatch, 710 Mutual Bank Bldg., Kansas City, Mo., Engrs.

Okla., Wynnewood—$85,000 bonds voted for extensions to water wks. plant and electrical system.

Pa., Mt. Union—Mount Union Boro. Water Works Co., having plans prepared and bids will be received in spring for 50,000,000 gals. reservoir at Singers Gap, 7 miles so. of Mt. Union. Rein. conc., earth or masonry. Will also include 4,000 ft. 8-in. cast iron pipe. $70,000. D. W. Dillman, 8081 Altoona Tr. Bldg., Altoona, Engr.

S. D., Watertown—Water filter will be installed at Lake Kampeska. Brownie Mather, City Aud. W. F. Cochrane, City Engr. $57,000.

Tenn., Union City—City plans to extend $50,000 for water main extensions. J. N. Woolsey, Mayor.

Tex., Beaumont—City Water Commission will expend $250,000 for extension of water mains.

Tex., Quanah—Town contemplates making extensive water wks. impvts., $98,000 available. Cons. Engrs., Elrod Engrg. Co., Interurban Bldg., Dallas.

Tex., Rosen Heights—(P. O. Ft. Worth)—Rosen Heights has petitioned City Comn. to install water works, sewerage system and electric lights; also extend gas system. City Secy. Mr. Snow.

W. Va., Huntington—Southern Point Oil Co., First National Bank Bldg., plans 15 mile pipe line and several pumping plants near here. Est. cost $100,000. L. H. Lipsey, Pres.

Wn., Port Angeles—Impvts. estimated to cost betw. $60,000 and $70,000, directed to be made in water sys. of No. Pacific Public Service Co. of Port Angeles, in order signed by Dept. Pub. Wks. recently. Impvts. are to be completed by July 1st.

Wis., LaCrosse—$50,000 bonds voted on for water mains here. E. J. Blake, City Engr. M. Birnbaum, City Clk.

Wis., Waupun—Plans being completed for one 60,000-gal. tank on new steel tower about 74-ft. high, one 60,000-gal. tank, 20-ft. diam. abt. 26-ft. high, to be built on present masonry tower. W. G. Kirchoffer, Madison, Cons. Engr. Thos. Greene, Pres. City Water Comn.

Wyo., Casper—Comn. advised floating of $150,000 bonds for reservoir and $50,000 for sewer work. Capy. of reservoir 6,000,000 gals. H. H. Price, City Clk.

BUYERS' GUIDE

Pumps.
De Laval Steam Turbine Co.
Evinrude Motor Co.
Harris Air Pump Company.
Keystone Driller Co.
Smith Co., T. L., The

Reinforcing For Pavements.
American Steel and Wire Co.
Truscon Steel Co.

Road Building Material.
Kentucky Rock Asphalt Co.
The Texas Co.

Road Binder.
The Barrett Co.
Pioneer Asphalt Co.
Standard Oil Co. (Indiana)
The Texas Co.
Uvalde Asphalt Paving Co.
Warren Bros. Co.

Road Forms.
Heltzel Steel Form & Iron Co.
Truscon Steel Co.

Road Graders.
Austin-Western Road Machinery Co., The
Good Roads Machinery Co., Inc.

Road Machinery.
Austin Machinery Corporation.
Austin-Western Road Machinery Co., The
Buffalo-Springfield Roller Co.
Cummer & Son Co., The F. D.
Good Roads Machinery Co., Inc.
Keystone Driller Co.
Littleford Brothers.
Warren Bros. Co.

Road Planer.
Austin-Western Road Machinery Co., The

Road Oil and Preservatives.
The Barrett Co.
Standard Oil Co. (Indiana)
The Texas Co.

Road Rollers.
Austin-Western Road Machinery Co., The
Buffalo-Springfield Roller Co.
Good Roads Machinery Co., Inc.

Rock Crushers.
Austin-Western Road Machinery Co.
The Good Roads Machinery Co., Inc.

Roofing Material.
The Barrett Co.
Carey Co., Philip, The.
Pioneer Asphalt Co.
The Texas Co.
Warren Bros. Co.

Sand Dryers.
Cummer & Son Co., The F. D.
Littleford Brothers.

Saw Rigs.
C. H. & E. Mfg. Co.

Scarifiers.
Austin-Western Road Machinery Co., The
Good Roads Machinery Co., Inc.

Scrapers, Drag Line.
Pawling & Harnischfeger.
Sauerman Bros.

Scrapers, Graders, Plows, Etc.
Austin-Western Road Machinery Co., The

Scrapers, Power.
Sauerman Bros.

Sewage Treatment.
Direct Oxidation Process Corp.

Sewer Braces.
Kalamazoo Fdry. & Mach. Co.
Dee Co., Wm. E.
Madison Foundry Co.

Sewer Cleaning Machinery.
Stewart, W. H.

Sewer Forms.
Heltzel Steel Form & Iron Co.

Sewer Pipe.
Cannelton Sewer Pipe Co.
Dee Clay Mfg. Co., W. E.

Sewer Pipe Joint Compound
The Barrett Co.

Sewer Rods.
Stewart, W. H.

Slide Rules.
Kolesch & Co.

Sluice Gates.
Coldwell-Wilcox Co.

Snow Removal Machinery.
Austin Machinery Corporation.
Good Roads Machinery Co., Inc.
Phoenix Mfg. Co.

Soaps—Liquid.
Integrity Chemical Co.

Special Castings.
The Flower Company.
U. S. Cast Iron Pipe & Fdy. Co.

Sprinklers.
Austin Machinery Corporation.
Austin-Western Road Machinery Co., The

Steel Joists, Studs and Sash.
Truscon Steel Co.

Steel Tapes.
Kolesch & Co.
Lufkin Rule Co., The

Stone Crushers.
Austin-Western Road Machinery Co., The

Stone Elevators.
Austin-Western Road Machinery Co., The

Stone Spreaders.
Austin-Western Road Machinery Co., The
Burch Plow Works Co.

Stone Screens.
Austin-Western Road Machinery Co., The
Littleford Bros.

Street Cleaning Machinery (Horse Drawn).
Austin-Western Road Machinery Co., The

Street Paving Material.
The Texas Co.

Street Sprinklers (Horse Drawn).
Austin-Western Road Machinery Co., The

Structural Steel.
Lewis-Hall Iron Works.

Subgrading Machines
Austin Machinery Corp.
The Hug Co.

Surveyors' Instruments.
Kolesch & Co.
Lufkin Rule Co., The

Sweepers.
Austin Machinery Corporation.
Austin-Western Road Machinery Co., The

Tamping Machines.
Pawling & Harnischfeger.

Tanks, Water Supply.
Littleford Brothers.

Tar and Pitch
The Barrett Co.

Tar Heaters.
Littleford Brothers.

Tarvia.
The Barrett Co.

Testing Chemists.
Dow & Smith.
Walter H. Flood.
Howard, J. W.
Kirschbraun, Lester.
Nutting Co., H. C.
Van Trump, Isaac.

Traction Engines (Oil or Kerosene).
Austin-Western Road Mach. Co.

Tractors.
Austin Machinery Corporation.
Holt Mfg. Co., Inc.

Traffic Signals.
Electrical & Specialty Supply Co.
Little Giant Co.

Trailers.
Lee Trailer and Body Co.

Trench Braces.
Kalamazoo Fdry. & Mach. Co.

Trench Machinery.
Austin Machinery Corporation.
Kalamazoo Fdry. & Machine Co.
Pawling & Harnischfeger.

Turbines, Steam.
De Laval Steam Turbine Co.

Turntables, Truck
The Hug Co.

Valves.
Coldwell-Wilcox Co.
The Flower Company.

Wall Coping.
Cannelton Sewer Pipe Co.

Warrenite.
Warren Bros. Co.

Water Main Cleaning.
National Water Main Cleaning Co.

Water Pipe.
U. S. Cast Iron Pipe & Foundry Co.

Waterproofing.
Barrett Co., The
Pioneer Asphalt Co.
The Texas Co.
Truscon Steel Co.

Water Purification.
Direct Oxidation Process Corp.
Pennsylvania Salt Mfg. Co.

Water Softener.
The Refinite Co.

Water Works Supplies and Equipment.
Coldwell-Wilcox Co.
The Flower Company.
Pennsylvania Salt Mfg. Co.

Wheeled Scrapers.
Austin-Western Road Machinery Co.

Wire Rope.
American Steel & Wire Co.

Windows (Steel).
Truscon Steel Co.

Wire-Cut Lug Brick.
Murphysboro Paving Brick Co.
Springfield Paving Brick Co.

Wood Block (Creosoted).
Barrett Co., The
Republic Creosoting Co.

Wood Preservatives.
Barrett Co., The
Republic Creosoting Co.

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The Mayor talked to the engineer,
As the engineer looked at him,
"Remember the days at the old swimmin' hole?
With Tom, Dick, Harry and Jim?
Remember the craze we had for tops,
How we matched, compared and noted—
Remember the buys, the trades and swaps,
How the best were the tops you 'toted'?"

The engineer answered His Honor,
As the engineer looked up at him,
"On 'tops' I still am a gonner,
I am hunting with vigor and vim—
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The ones that will meet every test—
And I find Warrenite-Bitulithic,
Of all 'tops' is the best."

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—Brick Rattlers
—Catch Basin Covers
—Cement Testing Machinery
—Clam Shell Buckets
—Contraction Joint
—Cranes, Locomotive
—Crushers, Stone
—Drag Scrapers
—Dragline Cableway Excavator
—Dump Cars
—Dump Wagons
—Excavator, Crane
—Elevating Graders
—Gasoline Locomotives
—Gravel Screener
—Heaters, Asphalt
—Heaters, Tar
—Hoisting Engines
—Industrial Cars
—Industrial Track
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—Mixers, Building
—Mixers, Hot
—Mixers, Paving
—Motor Trucks (1-3 tons)
—Motor Trucks (over 3 tons)
—Oil Distributors
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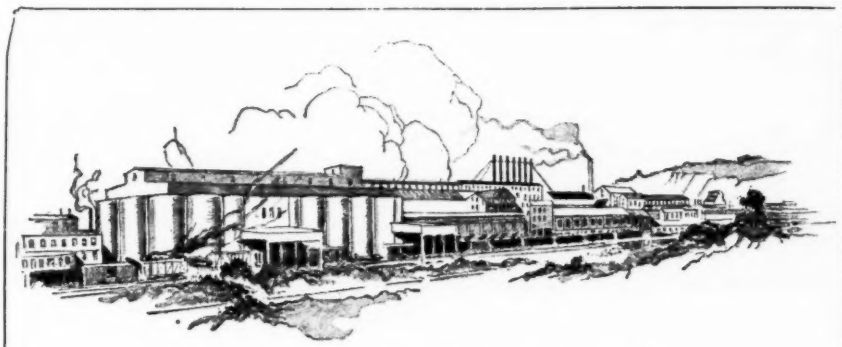
—Portable Drilling Rigs
—Pile Drivers
—Pumps
—Reinforcing Steel
—Road Drags
—Road Forms
—Road Graders
—Road Mesh
—Road Planes
—Road Plows
—Road Rollers
—Road Scrapers
—Sand Dryers
—Saw Rigs
—Scarifiers
—Scrapers, Power
—Sheet Piling, Steel
—Skimmer, Scoop
—Steam Shovels
—Stone Elevators
—Stone Screens
—Stone Spreaders
—Surface Heaters
—Tampers, Road
—Tractors
—Trailers
—Turntables
—Unloaders, Car
—Wagon Loader
—Wheeled Scrapers
—Wire Mesh



If you couldn't get cement

MOST of the country's construction projects, large and small, would quickly stop if you couldn't get cement.

Most work could not even start without cement for foundations. With this in mind let's see where the cement industry stands today.

Last year the country used over 460,000,000 sacks of portland cement. Capacity to manufacture was nearly 600,000,000 sacks.

Cement cannot be made everywhere, because raw materials of the necessary chemical composition are not found in sufficient quantities everywhere.

It is now manufactured, however, in 27 states, and there are 117 plants—some one or more within easy shipping distance of nearly every part of the country.

Conservative estimates place the capital invested in the cement industry at $300.000,000, and value of output for the last 5 years at $860,000,000.

Capital requirements are large—turnover is slow—on an average less than 3 times in 5 years.

Providing an adequate cement supply has involved a good deal in costly experience.

159 cement plants have been built, most of them in the last 25 years — 166 others went through some stage of construction or financing; only 117 have survived the financial, operating and marketing hazards of that period.

The capacity of these plants is 30 per cent greater than the record year's demand.

PORTLAND CEMENT ASSOCIATION

A National Organization
to Improve and Extend the Uses of Concrete

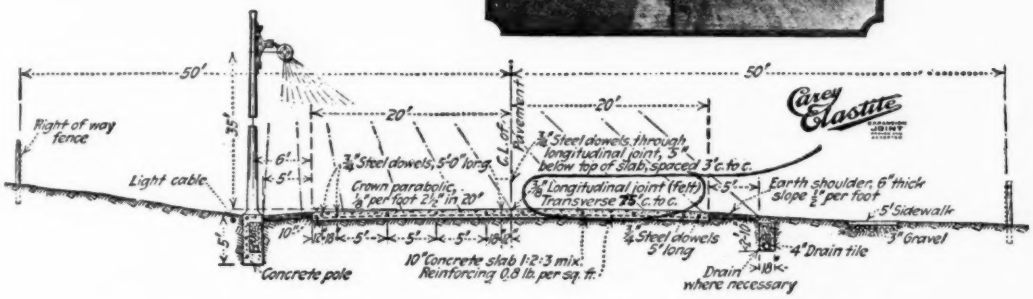
Atlanta	Des Moines	Los Angeles	Parkersburg	San Francisco
Boston	Detroit	Milwaukee	Philadelphia	Seattle
Chicago	Helena	Minneapolis	Pittsburgh	St. Louis
Dallas	Indianapolis	New Orleans	Portland, Oreg.	Vancouver, B.C.
Denver	Kansas City	New York	Salt Lake City	Washington, D.C.

Water Works Equipment Service

If in the market for any of the following water works equipment, so indicate by check marks, mail this page to ***Municipal and County Engineering,*** 702 Wulsin Building, Indianapolis, and price quotations and descriptive literature will be forwarded to you.

—Air Compressors
—Air Lift Pumps
—Ash Handling Mach'y
—Backfillers
—Brass Goods
—Chimneys
—Chloride of Lime
—Chlorinators
—Coal Handling Machinery
—Concrete Hoisting Equipment
—Concrete Tanks
—Condensers
—Conduit Rods
—Cranes, Locomotive
—Cranes, Traveling
—Curb Boxes
—Curb Cocks
—Derricks, Pipe Laying
—Derricks, Steel Portable
—Drinking Fountains
—Dry Feed Chemical Apparatus
—Engines, High Duty
—Engines, Gas
—Engines, Oil
—Engines, Pumping
—Explosives
—Fence, Iron
—Fittings, Wrought
—Filter Equipment
—Gates, Sluice
—Gauges, Recording
—Gauges, Steam
—Gauges, Water
—Goose Necks
—Hydrants, Fire
—Indicator Posts
—Lead
—Leadite
—Lead Furnaces
—Lead Wool
—Leak Indicators
—Liquid Chlorine
—Lime
—Meter Boxes
—Meter Couplings
—Meter Testers
—Motor Trucks
—Motors, Electric
—Oil, Lubricating
—Pipe, Cast Iron
—Pipe Cutters
—Pipe, Lead-Lined
—Pipe, Steel
—Pipe, Wrought Iron
—Pipe, Wooden
—Pitometers
—Pumps, Air Lift
—Pumps, Boiler Feed
—Pumps, Centrifugal
—Pumps, Deep Well
—Pumps, Steam
—Pumps, Trench
—Pumps, Turbine
—Pumping Engines
—Service Boxes
—Soda Ash
—Specials, Cast Iron
—Standpipes
—Steam Boilers
—Steel, Reinforcing
—Sulphate of Alumina
—Tamping Machines
—Tanks, Elevated
—Tapping Machines
—Trench Braces
—Trenching Machines
—Valve Boxes
—Valve Inserters
—Valves, Gates
—Valves, Pressure Regulating
—Water Main Cleaners
—Water Meters
—Water Softening Plants
—Welding Apparatus
—Well Drills
—Well Screens
—Well Strainers

The "Ideal Section" of the Lincoln Highway near Dyer, Indiana. Stone & Webster, Boston, Mass., Engineering Contractors in charge of construction, assisted by Lockwood, Green & Co., Detroit, Mich., Consulting Engineers. Jen Jensen, Chicago, Ill., Landscaping. J. C. O'Connor & Sons, Fort Wayne, Ind., Contractors. Carey Elastite Expansion Joint used as transverse and longitudinal joints.



Carey Elastite Expansion Joint chosen for the "Ideal Section"

Features of the "Ideal Section"

Standard width of right-of-way, 100 feet. Paving width, 40 feet. Four traffic lanes. Accommodation for 15,000 passenger automobiles per 24 hour day at 35 miles per hour, and 5,000 motor trucks every 24 hours at 10 miles per hour. Thickness of concrete, 10 inches, reinforced with 80 lb. steel per 100 sq. ft. No curves less than 1,000 feet radius. Curves super-elevated for speed of 35 miles per hour. Crossings at grade eliminated. Foot-path for pedestrians. Embankments over 3 feet high guarded by rail. Uniform markers for distance and direction. Comfort station and a camp site acreage. Special illumination for night driving. Wiring carried in underground cables. Drainage taken care of underground; no open ditches.

THE Ideal Section of the Lincoln Highway is a one and one-half mile length between Dyer and Schererville, Ind., 32 miles south of Chicago.

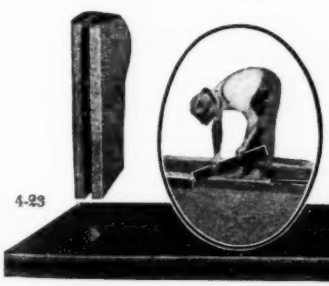
"Its proponents," writes Mr. W. G. Thompson, Consulting Engineer for the Ideal Section, "do not set it up as a pattern to be minutely followed, but as a guide, hoping that the general principles may be adopted and improved on when routes of heavy travel are being considered."

Ideas secured from questionnaires to 4,600 highway engineers are embodied in the design.

Carey Elastite Expansion Joint is used in the "Ideal Section" as transverse joints every 75 feet and is also used as a longitudinal center joint.

THE PHILIP CAREY COMPANY
40 Wayne Avenue, Lockland, Cincinnati, Ohio

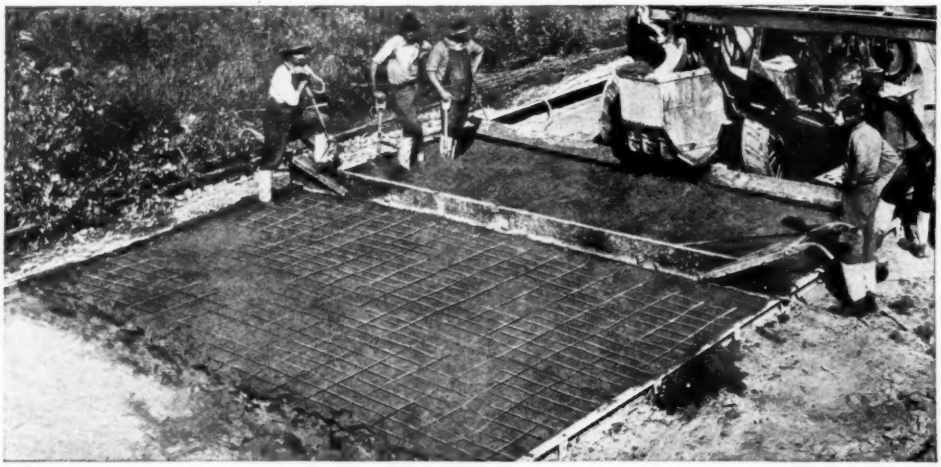
Made like a sandwich
installed like a board



Carey Elastite
TRADE MARK REG. U.S. Pat. Office
EXPANSION JOINT
PROVED AND ACCEPTED

Carey Elastite Expansion Joint is an asphaltic body sandwiched between two walls of asphalt-saturated felt, making an elastic, compressible joint. Made in any dimensions, cut to crown or special shape, and comes to the job ready to use.

4-23



Palestine Road, Darlington County, Pa. Chester Contracting Co., Contractors.

Leading Highway States Reinforce Concrete Roads

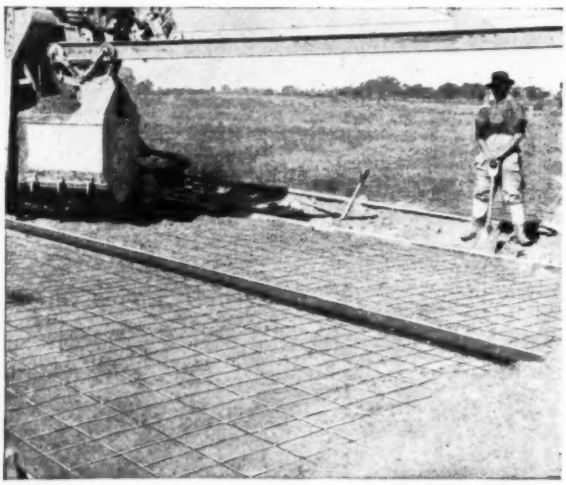
The necessity of steel reinforcement in concrete roads is now generally recognized by leading engineers. The State Highway Departments of New York, Pennsylvania, New Jersey, Ohio, Maryland, Minnesota, Iowa, Florida, North Carolina, California and others, are specifying steel wire mesh in flat sheets.

TRUSCON WIRE MESH

Furnished in widths and areas as desired, in flat sheets. Members are rigidly connected so that mesh remains in perfect form during handling. The sheets are manufactured with the main members spaced 6 inches on centers, and the secondary members spaced 12 inches on centers. Cut in any desired length.

TRUSCON STEEL CO., Youngstown, Ohio

Warehouses and Offices from Pacific to Atlantic.
For address see phone books of principal cities. Canada: Walkerville, Ont. Export Division: New York.



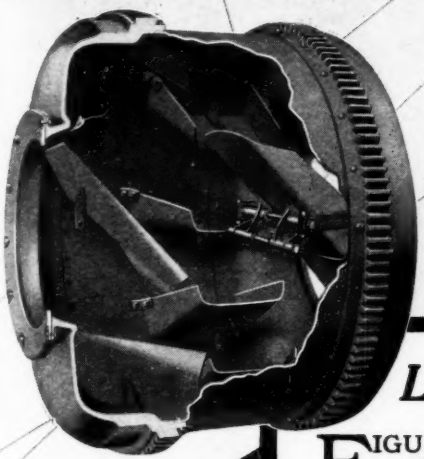
Southfield Road, Oakland County, Mich. R. D. Baker Co., Contr., L. V. Belknap, Eng. A central contraction joint was placed in this road.

TRUSCON CONTRACTION JOINTS

16-gauge plate, rigid, substantial, easy to install. Provides a definite plane of weakness in pavement that forms a straight crack for contraction or expansion. Central joints also serve as traffic markers.

TRUSCON STEEL CO
TRUSCON
HIGHWAY PRODUCTS

KOEHRING



Liberal Capacity

FIGURE the actual cubic capacity of a Koehring drum — you will discover that every rated capacity is generously justified, giving plenty of room for proper mixing action.

Drum heads are cast of special composition metal to resist abrasion — an important feature when big capacity mixers and longer mixing time are considered. No pockets or corners to clog. Easily renewable splash ring. Study the Koehring drum, a good example of Koehring "Heavy Duty" construction.

CAPACITIES

Construction Mixers: 10, 14, 21, 28 cu. ft. mixed concrete. Write for Catalog C-10. ***Pavers:*** 7, 10, 14, 21, 32, cu. ft. mixed concrete Write for Catalog P-10.

Dandie: Light mixer, 4 and 7 cu. ft. mixed concrete; power charging skip, or low charging platform. Light duty hoist. Write for Catalog D-10.

KOEHRING COMPANY

MILWAUKEE, WISCONSIN

Foreign Department, Room 1370, 50 Church St., New York City.

Canada, Koehring Company of Canada, Ltd., 105 Front St., East Toronto, Ontario

Mexico, F. S. Lapum, Cinco de Mayo 21, Mexico, D. F.

KOEHRING HEAVY DUTY

Considers His P & H Excavators Best All-Around Machinery He Ever Owned

WESTERN UNION TELEGRAM

NEWCOMB CARLTON, PRESIDENT GEORGE W. E. ATKINS, FIRST VICE-PRESIDENT

Send the following message, subject to the terms on back hereof, which are hereby agreed to

WILMINGTON, N. C. AUG. 17, 1922.

D. M. PHILLIPS
C/O TEXAS COMPANY
HOUSTON, TEXAS.

I HAVE THREE, TWO NAUGHT SIX, P & H MACHINES, TWO AS DRAGLINES AND ONE AS SHOVEL. THE SHOVEL NOW LOADING LIMESTONE ROCK FOR CRUSHER PLANT AND GIVING EXCELLENT RESULTS. I EXPECT NOW TO REPLACE ALL MY STEAM MACHINES WITH THIS TYPE SHOVEL AS I CONSIDER THEM THE BEST ALL ROUND PIECE OF MACHINERY I EVER OWNED.

C. W. LACY

C. W. LACY
Contractor
P. O. Box 344

Wilmington, N. C. June 23rd. 1922.

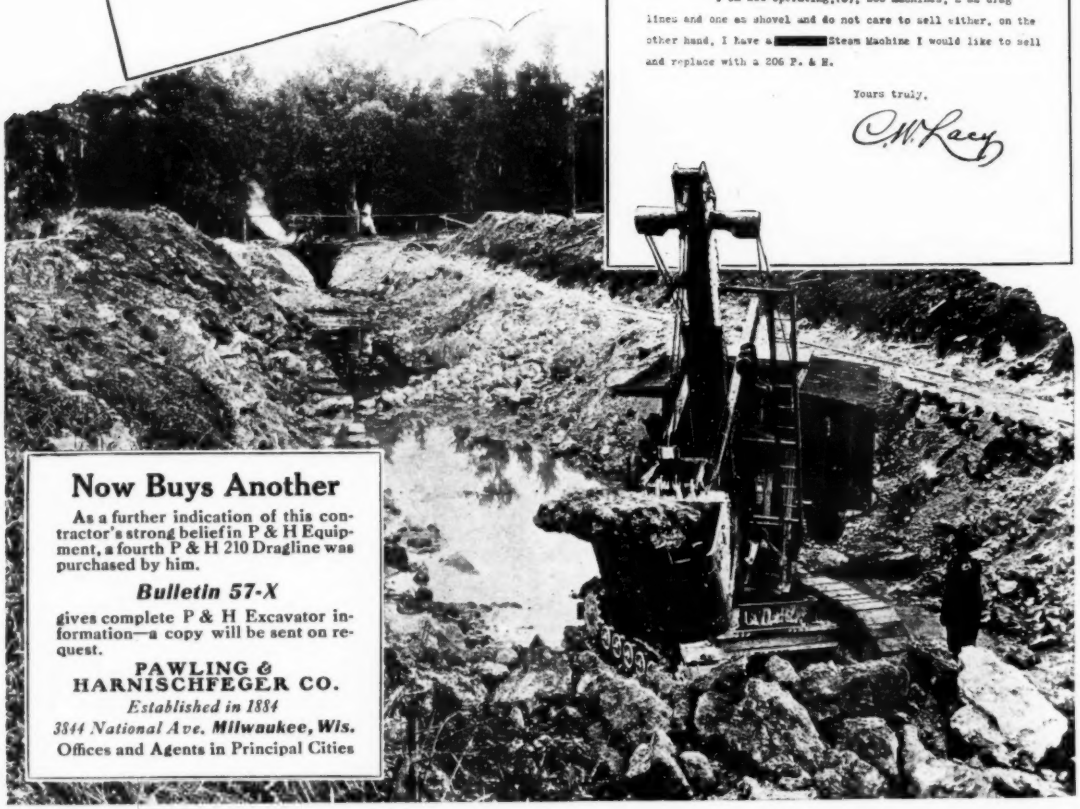
H. B. Hoppendietzel Construction Co.
General Contractors,
Macon, Ga.
Gentlemen:-

Replying to your letter, 21st. inst. asking if I had a P. & H. 206 Machine for sale, will say that I have not.

I am now operating,(3), 206 machines, 2 as drag lines and one as shovel and do not care to sell either, on the other hand, I have a [redacted] Steam Machine I would like to sell and replace with a 206 P. & H.

Yours truly,

C. W. Lacy



Now Buys Another

As a further indication of this contractor's strong belief in P & H Equipment, a fourth P & H 210 Dragline was purchased by him.

Bulletin 57-X

gives complete P & H Excavator information—a copy will be sent on request.

PAWLING & HARNISCHFEGER CO.

Established in 1884

3844 National Ave. ***Milwaukee, Wis.***

Offices and Agents in Principal Cities

PAWLING & HARNISCHFEGER CO. P AND H The TREAD MARK of P&H EQUIPMENT

GASOLINE SHOVEL

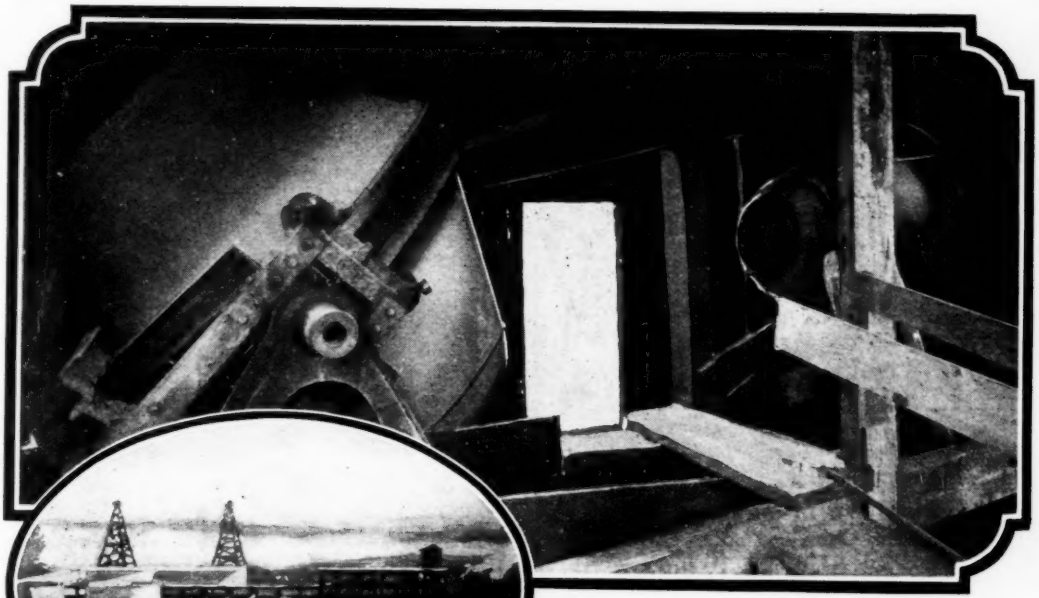


Photo courtesy Thompson-Starrett Co,. Contractors

Placing 50,000 Cubic Feet of Concrete in Four Months

The 50,000 cu. yds. of concrete used in the substructure of the Detroit Filter Plant were mixed in Smith Tilting Mixers shown above, located at a central mixing plant.

The pull of a lever tilts the mixer and the mixed concrete flows rapidly into waiting 5-ton buckets which carry it to the job.

For this sort of work nothing has been yet devised but the Smith Tilting Mixer for thoroughness of mix combined with speed of discharging.

Over 15,000 of this one type of Smith Mixer are in use in all parts of the world—the world's largest mixers being of this type—used at Muscle Shoals.

Smith Tilting Mixers are made in standard sizes of 10, 21, 28, and 56 cu. yds. mixed batch capacities. They are described in Bulletin 406. Copy sent to you at your request.

A Smith-Mixed Concrete Job is a lasting monument to the contractor's integrity.

Though quiet in action (a reason for unusual long life) the end-to-center mixing of the aggregate produces the thorough hydrating and coating necessary to insure enduring concrete. Smith-mixed concrete a quarter-of-a-century old has proven that this thorough mixing is important—and concrete in use, exposed to wear, vibration, and all kinds of weather provides a far better test of value than all laboratory tests put together.

The Smith drum is a clean drum, made of boiler plate steel, so that there are no accumulations or clogging to interfere with the thorough end-to-center-mixing action.

THE T. L. SMITH COMPANY

1181 32nd Street **Milwaukee, Wis.**

New York Office and Warehouse: 50 Church Street
Chicago Office: Old Colony Building
Western Warehouse: Oakland, California
Agents in Principal Cities

SMITH MIXERS

Concrete Roads must be reinforced

It is demonstrated beyond doubt that to make concrete roads proof against heavy motor traffic, weather and time a fabric of steel must be incorporated in the concrete.

Several great States have so ruled.

American Steel and Wire Company's

Concrete Reinforcement

Fulfills every engineering requirement.

Send for our booklet on road building.

CHICAGO
NEW YORK
CLEVELAND
PITTSBURGH
DENVER

STEWART SEWER CLEANING MACHINE

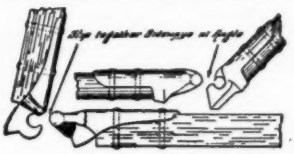
Water Cleaning System, if you wish it, or Drag Bucket type.

Also have TURBINE SEWER CLEANING MACHINE at Low Price.

WE WILL PAY FREIGHT AND CHARGE TO BILL.

We Ship Rods for Trial—who else will do this?

We also make a Rod that will float. Also Rods with wheels for conduit work.



SEWER AND CONDUIT RODS

No Deep Shoulder Cut for Couplings. Rods retain full size and strength.

Investigate our JUMBO ROD

W. H. STEWART

1614 Locust Street . . ST. LOUIS, MO.
129 George Street . . BOSTON, MASS.

CANADA FACTORY, WALKERVILLE, ONT.
Therefore No Duty for Purchaser to Pay.

PACIFIC COAST DELIVERIES MADE FROM SAN FRANCISCO.

CUMMER ASPHALT PLANTS

Portable Road Plants (Three Units)
Four Sizes, 750, 1250, 1800 and 2000 square yards 2-inch top per day.

One Car—Steam Melting
Capacity 2000 square yards 2-inch top daily.

Over 300 plants in successful operation.

Cummer plants never wait for hot sand.

Prompt Shipment on All Plants.

The F. D. Cummer & Son Co., Cleveland, Ohio.

WM. E. DEE CLAY MFG. CO.

Proprietors of MECCA CLAY WORKS

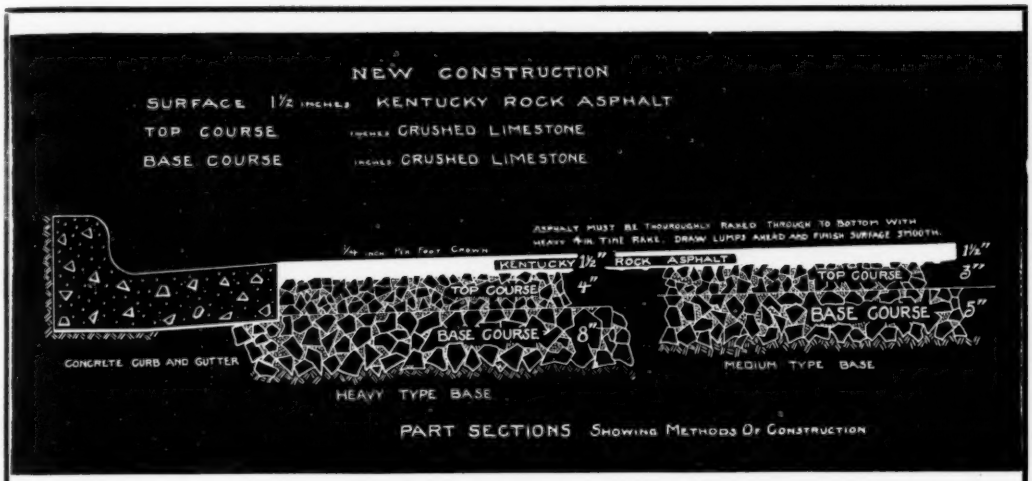
Manufacturers of

STANDARD AND DOUBLE STRENGTH

Sewer Pipe, Drain Tile, Culvert Pipe, Well Tubing, Flue Lining, Wall Coping and Fire Brick.

WORKS { Mecca, Parke County, Ind., on C. & E. I. R. R.
Newport, Vermillion County, Ind., on C. & E. I. R. R.

Chicago Office,
30 N. LaSalle Street.


NEW CONSTRUCTION
SURFACE 1½ INCHES KENTUCKY ROCK ASPHALT
TOP COURSE INCHES CRUSHED LIMESTONE
BASE COURSE INCHES CRUSHED LIMESTONE
ASPHALT MUST BE THOROUGHLY RAKED THROUGH TO BOTTOM WITH HEAVY 4-IN. TINE RAKE. DRAW LUMPS AHEAD AND FINISH SURFACE SMOOTH.
¼ INCH PER FOOT CROWN
KENTUCKY ROCK ASPHALT 1½"
TOP COURSE 4"
BASE COURSE 8"
CONCRETE CURB AND GUTTER
HEAVY TYPE BASE
TOP COURSE 1½"
3"
BASE COURSE 5"
MEDIUM TYPE BASE
PART SECTIONS Showing Methods Of Construction

Asphalt Pavements at Reasonable Cost

Kentucky Rock Asphalt builds the finest sheet asphalt pavements at a cost comparable with that of lower and less durable types. The great saving is due to the fact that the material is ready mixed and laid COLD on any standard base sufficient to carry the traffic.

No costly mixing plant, no asphalt experts are needed. No special binder course is required. Shovels, rakes and roller is the only equipment necessary.

The finished Kentucky Rock Asphalt surface is smooth and resilient. It does not crack, roll, buckle or bleed.

Above is shown a typical cross section of Kentucky Rock Asphalt surface on two-course rolled stone base. This construction has been extensively used with great satisfaction and, at a considerable saving in regions where lime stone is available. Our engineering department has prepared typical plans and specifications for various types of construction and re-construction, which will be sent to engineers and officials on request.

Kentucky Rock Asphalt is recognized as one of the standard high type pavements. It has been included in the specifications of ten states for heavy traffic roads built under federal aid. Scores of cities and counties have adopted it for new construction, re-construction and maintenance.

The "Kyrock" brand of Kentucky Rock Asphalt is produced only by this company in its plant at Kyrock, Ky. Back of this trade mark is the largest and oldest producer of Kentucky Rock Asphalt. Kyrock insures responsibility, ability to deliver and uniformity of material.

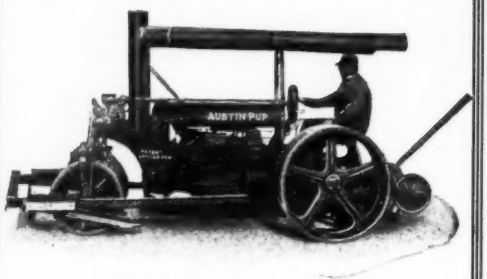
Write for Booklet E-5

Kentucky Rock Asphalt Co.

(INCORPORATED)

711-717 Marion E. Taylor Bldg. Louisville, Ky.

Announcing the Arrival
OF THE
AUSTIN PUP



WEIGHT, THREE TONS

Inspired by the demand for a roller that will

Level and roll sub-grade; pull a plow or scraper; act as a general purpose roller and tractor

For Contractors

Scarify, level and roll gravel and earth roads; prepare old roads for re-surfacing, and then roll the new material; act as an all-around roller and maintainer

For County, Township, Village, and other Public Officials

And best of all—

Cost little to buy and to operate; and next to nothing to maintain.

A SPECIAL ANNOUNCEMENT GIVES FULL DETAILS

Act quick if you want one of the first litter

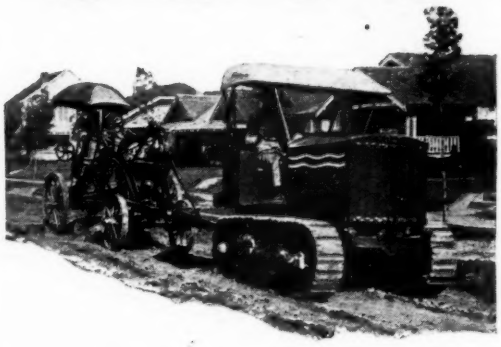
The Austin-Western Road Machinery Co.

Home Office - CHICAGO

Branches, Warehouses and Service Stations in 23 Cities

EXPORT DEPARTMENT
ALMACOA ALLIED MACHINERY COMPANY OF AMERICA ALMACOA
[illegible]

"Everything from a Drag Scraper to a Road Roller"



Modernize *Your* Equipment

Are the dirt and gravel streets and alleys of your town graded and maintained as they should be—or are they muddy and full of ruts? Now is the time to put the "Caterpillar"* to work. Your town doesn't own a "Caterpillar"*? It should. R. H. Kimball, Superintendent of Paving, Colorado Springs, says: "In two years our "Caterpillar"* already has done sufficient work to wipe off entirely its first cost, and we expect it to give more years of satisfactory service." Progressive cities and towns all over the country are using "Caterpillars"* exclusively because no other machine can provide such economical power for grading, leveling, maintenance, scarifying, hauling material, snow removal, and other public works. Bring your road working equipment up-to-date with "Caterpillars."*

**There is but one "CATERPILLAR"—Holt builds it*

THE HOLT MFG. COMPANY, *Inc.*
PEORIA, ILLINOIS

BRANCHES AND SERVICE STATIONS ALL OVER THE WORLD

Eastern Division: 50 Church St., New York

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Canadian Holt Company, Ltd., Montreal.

CATERPILLAR
Reg. U.S. Pat. Off.

HOLT
PEORIA, ILL.
STOCKTON, CALIF.

1/3 more per dollar

THE most significant evidence of the success of our new explosive, Dumorite, is the increase in volume of sales and the very large proportion of repeat orders.

The reason is simply this—it cuts blasting costs. It runs 135 to 140 sticks to the case as against 100 sticks of "40%", shoots with it, stick for stick, and costs the same per case.

It will pay *you* to investigate. Write our nearest branch office.

NON-HEADACHE DU PONT NON-FREEZING

DUMORITE

THE LATEST OF A COMPLETE LINE OF DU PONT EXPLOSIVES

Nitroglycerin, ammonia, gelatin and other types of explosives designed to meet every blasting requirement at least expense.

Branch Offices:
Birmingham, Ala.
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Sewerage Sewage Disposal Drainage
Appraisals Power Generation
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CITY-WASTES DISPOSAL CO.
(Organized from Staff of Col. Geo. E. Waring, Jr.)
Consulting Engineers. Specialists in Drainage, Sewerage and Sewage Disposal. Preliminary Investigations and Estimates, Surveys, Plans and Supervision. Sanitary Examinations and Reports.
45 Seventh Ave. NEW YORK.

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CHEMICAL ENGINEERS
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A. W. DOW, Ph. B., - Mem. Amer. Inst. Ch. Engrs.
F. P. SMITH, Ph. B., - Mem. Amer. Soc. Civil Engrs.
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Engineering Experts to Municipalities
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Water Works—Sewer Systems—Pavements—City Planning—Electric Light Plants—Hydro-Electric Developments—Mechanical Equipment—Fire Protection Engineers.
Plan Now for Future Construction.

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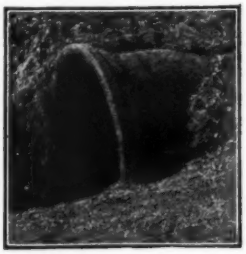

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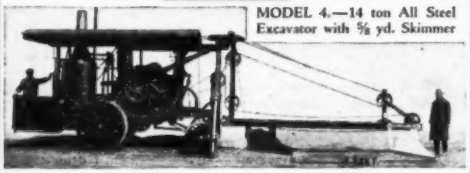

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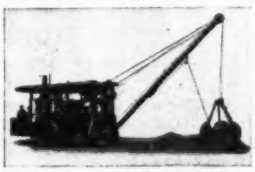

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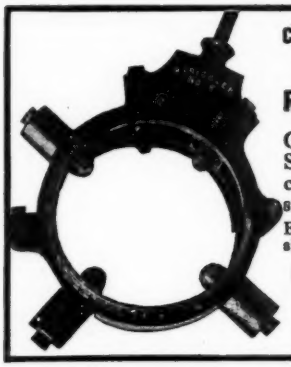

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